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DIRECT COURSE EXPERIMENT NO. 7360

A System for Recording Radio Noise from the DIRECT COURSE Event

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Technical Report

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IRIG
RF Interference
Instrumentation Recorder
Analog Recording

19. ABSTRACT (Continue on reverse if necessary and identify by block number)

This report documents the design and fabrication of the wideband noise recording unit developed for DIRECT COURSE experiment No. 7360. A complete set of drawings is included.

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18. SUBJECT TERMS (Continued).

Dust-Induced Lightning
High Explosive Testing
Impulsive Noise

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

LIST OF ILLUSTRATIONS (Concluded)

LIST OF TABLES

SECTION 1

INTRODUCTION

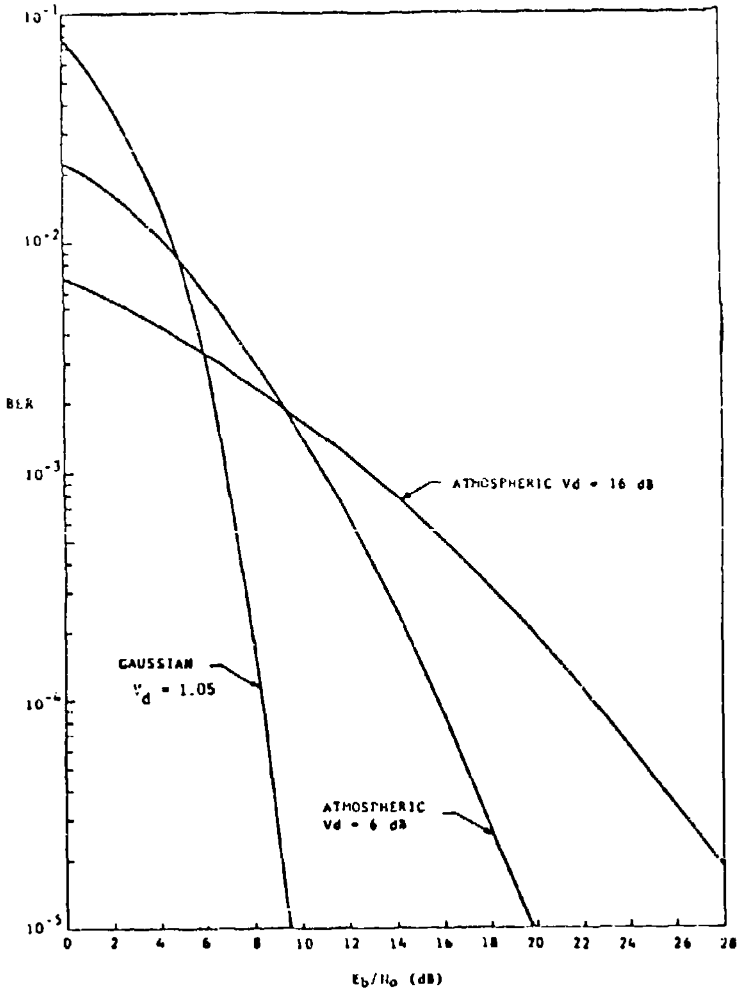
1-1 BACKGROUND

Voice and data radio communication systems are extremely critical to U.S. Strategic and Theater C3 systems. The performance of these radio links is limited by external noise of various types: atmospheric, galactic, thermal and event-induced. This experiment is principally concerned with the impulsive noise generated by high energy explosive tests. Figure 1 shows representative atmospheric noise statistics parametric in voltage deviation, Vd, the measure of impulsiveness, in dB. The figure shows that as Vd increases, the bit error rate (BER) increases at high Eb/No and decreases at lower values of Eb/No.

A typical HF system must be designed to have a sufficiently high signal to noise ratio (SNR) to operate in or to the right of the cross-hatched region depicted in Figure 2. For an SNR greater than approximately 30 dB, the character error rate (CER) will typically be less than 0.001.

Vd, which results from lightning is assumed to follow a gaussian distribution, however on a local scale, Vd is non-gaussian.

There are well documented but little understood observations of lightning in dust and volcanic clouds. Since these phenomena appear to exhibit an impulsive behavior similar to lightning, they may have very serious effects on communication systems.



- IMPULSIVENESS, VD, RMS TO AVERAGE NOISE ENVELOPE VOLTAGE
- PULSE DURATION
- PULSE SPACING

Figure 1. Atmospheric noise statistics.

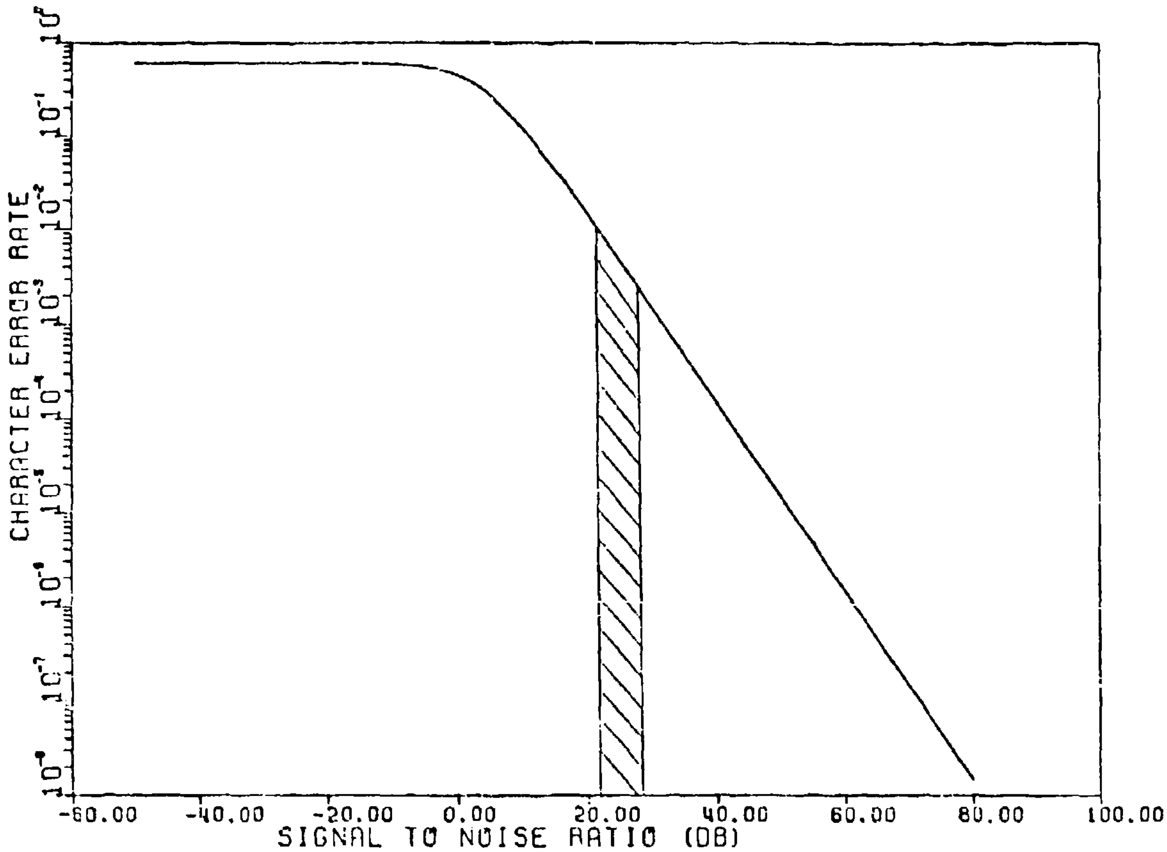


Figure 2. Typical HF data link performance.

A similar mechanism for dust cloud generation is large yield nuclear ground bursts. The purpose of this experiment is to use high explosive (HE) testing to simulate the dust effects of a nuclear ground burst with the hope of understanding the charging mechanisms in order to model them in a way that can be scaled to nuclear proportions.

1-2 OBJECTIVES.

The major goal of this experiment is to obtain high fidelity, wideband (10-600 KHz) analog recordings of the time domain signals that occur in the multiple frequency bands of interest to DNA/BMO/BMD, as a result of the DIRECT COURSE High Explosive event.

These recordings were made on a 14-channel EMI-7000A, IRIG specification, dc powered instrumentation recorder deployed at the test site. Figure 3 illustrates typical government frequency utilizations together with the bands selected for Experiment 7360 recording.

The noise recording system is designed to operate in bands designated in Table 1 with low and high gain channels to insure an adequate dynamic range of 70dB.

Additionally, provisions were made to allow taking field strength measurements of one or more known signals in each frequency band. This data will be used to determine the relative amplitude of the noise impulses.

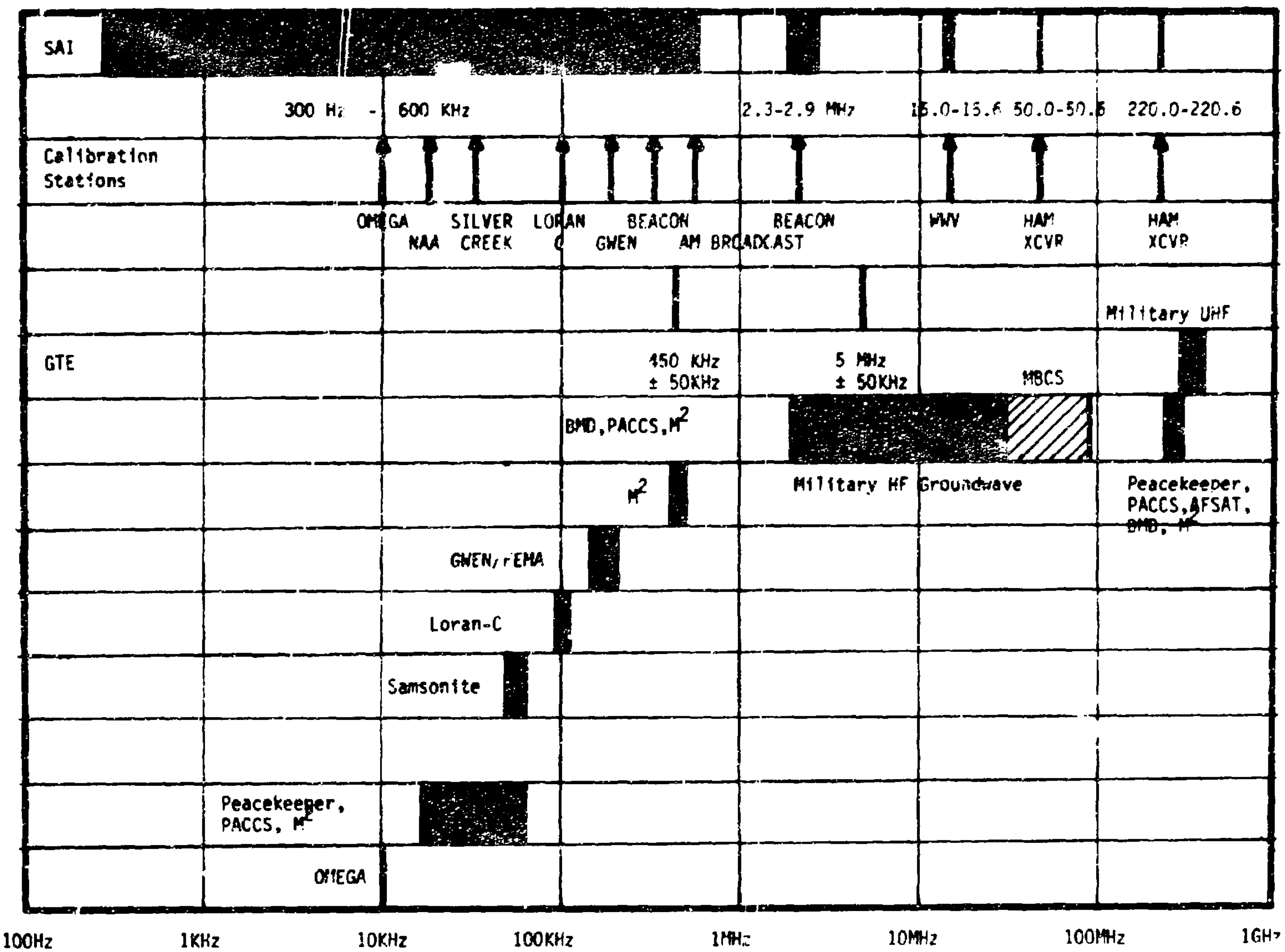


Figure 3 Frequency Utilization Chart

Table 1. Noise recording system channel configurations.

Channel	Frequency	Gain	Antenna
1	0.3-600 KHz	Low	Orthogonal(1) Loop
2	0.3-600 KHz	High	Orthogonal(1) Loop
3	0.3-600 KHz	Low	Broadside(2) Loop
4	0.3-600 KHz	High	Broadside(2) Loop
5	2.3-2.9 MHz	Low	Vertical Monopole
6	2.3-2.9 MHz	High	Vertical Monopole
7	15.0-15.6 MHz	Low	Vertical Monopole
8	15.0-15.6 MHz	High	Vertical Monopole
9	50.0-50.6 MHz	Low	Horizontal Yagi
10	50.0-50.6 MHz	High	Horizontal Yagi
11	220.0-220.6 MHz	Low	Horizontal Yagi
12	220.0-220.6 MHz	High	Horizontal Yagi
13*	----	----	-----
14*	----	----	-----

(1) Main beam pointed toward ground-zero (GZ)
(2) Null pointed toward GZ

NOTE: The EMI-7000A has 14 channels. Only 12 were used in this experiment.

SECTION 2

EQUIPMENT DESIGN

2-1 GENERAL.

Figure 4 is a block diagram of noise recording system showing all major elements. The equipment consists of several components designed around the EMI-7000A 14-channel instrumentation recorder. Figure 5 gives a summary of the recorder specifications.

Figure 6 shows the three main chassis designed and built under subcontract by RADANT Systems, Inc., 255 Hudson Road, Stow, MA. Appendix A contains the system specifications provided by the subcontractee. In the left foreground is the chassis containing power supply and its regulation circuit boards, the 10 MHz distrubution amplifier, the local oscillators (in shielded boxes), and the 220 MHz front-end electronics.

In the left background is the chassis containing the front-end preamplifiers, the mixer stages and the channel splitters for the 15, 50 and 220 MHz channels. On the right is the 12-channel delay equalization amplifier.

Figure 7 shows the Empire NF-105 field strength meter and ist accessories. This piece of equipment is used to measure the absolute field strengths of the marker beacons, such as Cutler, ME, on 17.8 kHz and Loran-C on 100 kHz, in order to later determine relative field strengths of the recorded noise.

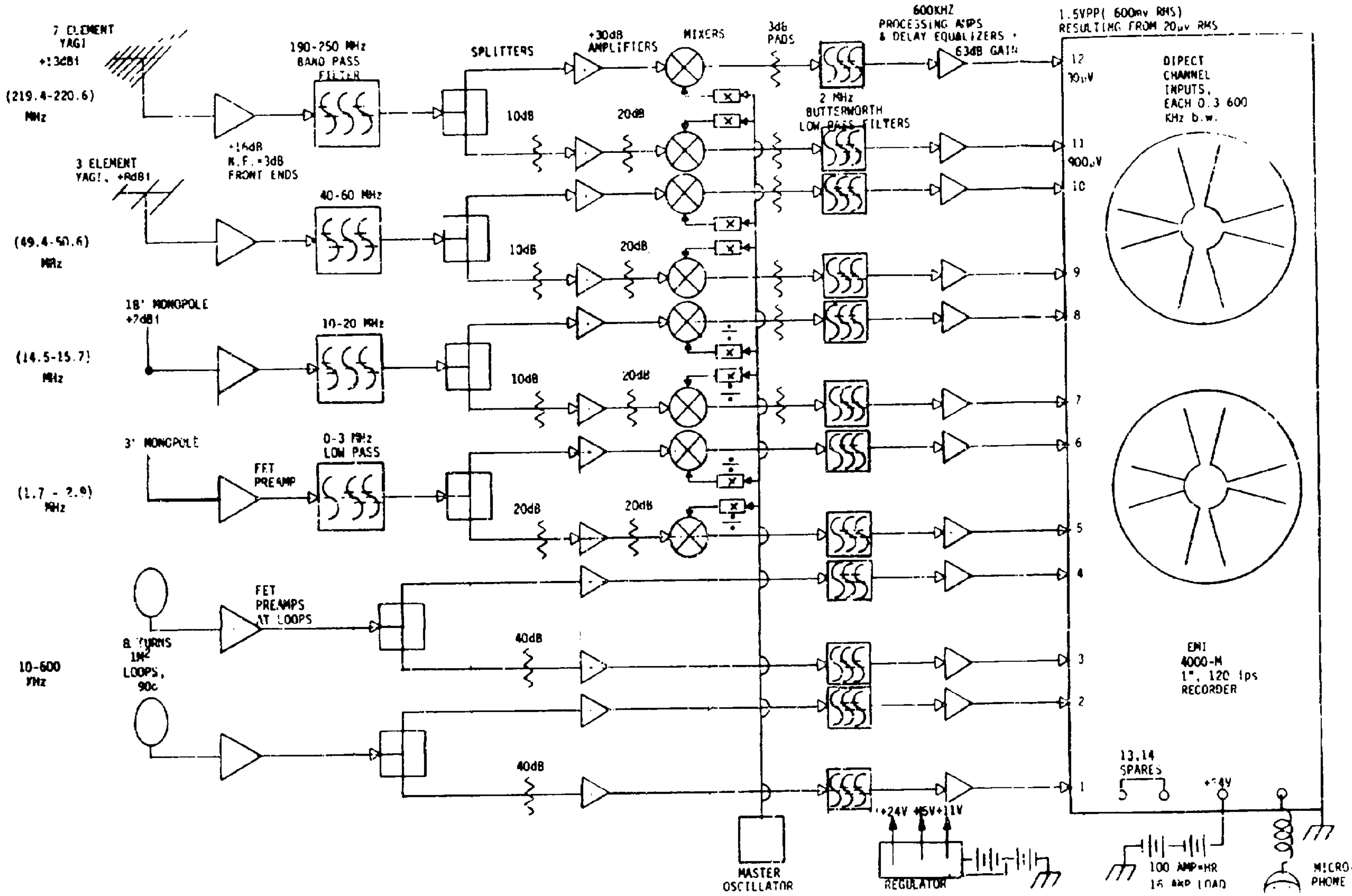


Figure 4. Noise Recording System

- 14 DIRECT TRACKS:
  - 0.3-600 KHZ B.W. @ 120 IPS
  - 40 DB SNR
- 1" IRIG SPEC # 106.73
- DC POWERED, 24 V, 16 AMPS
- 26 x 16 x 15"
- 51 LBS
- 8.5 MINS/TAPE REEL (AMPEX 797)

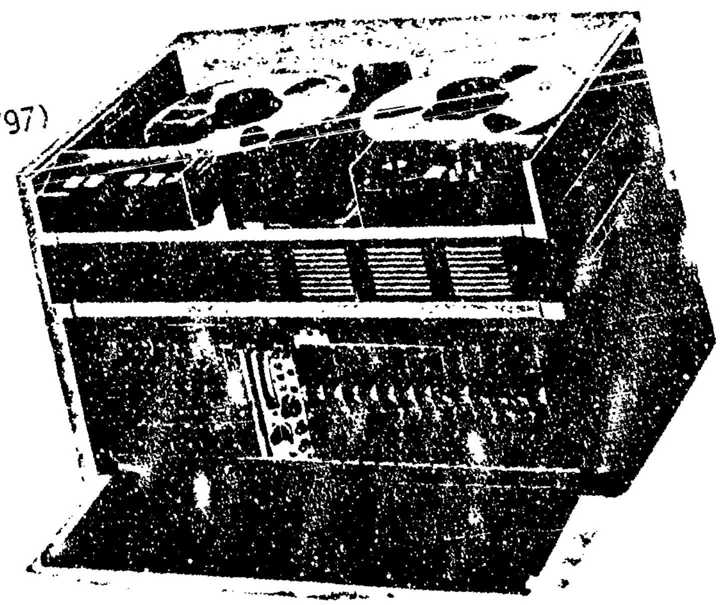


Figure 5. EMI 7000-A recorder.

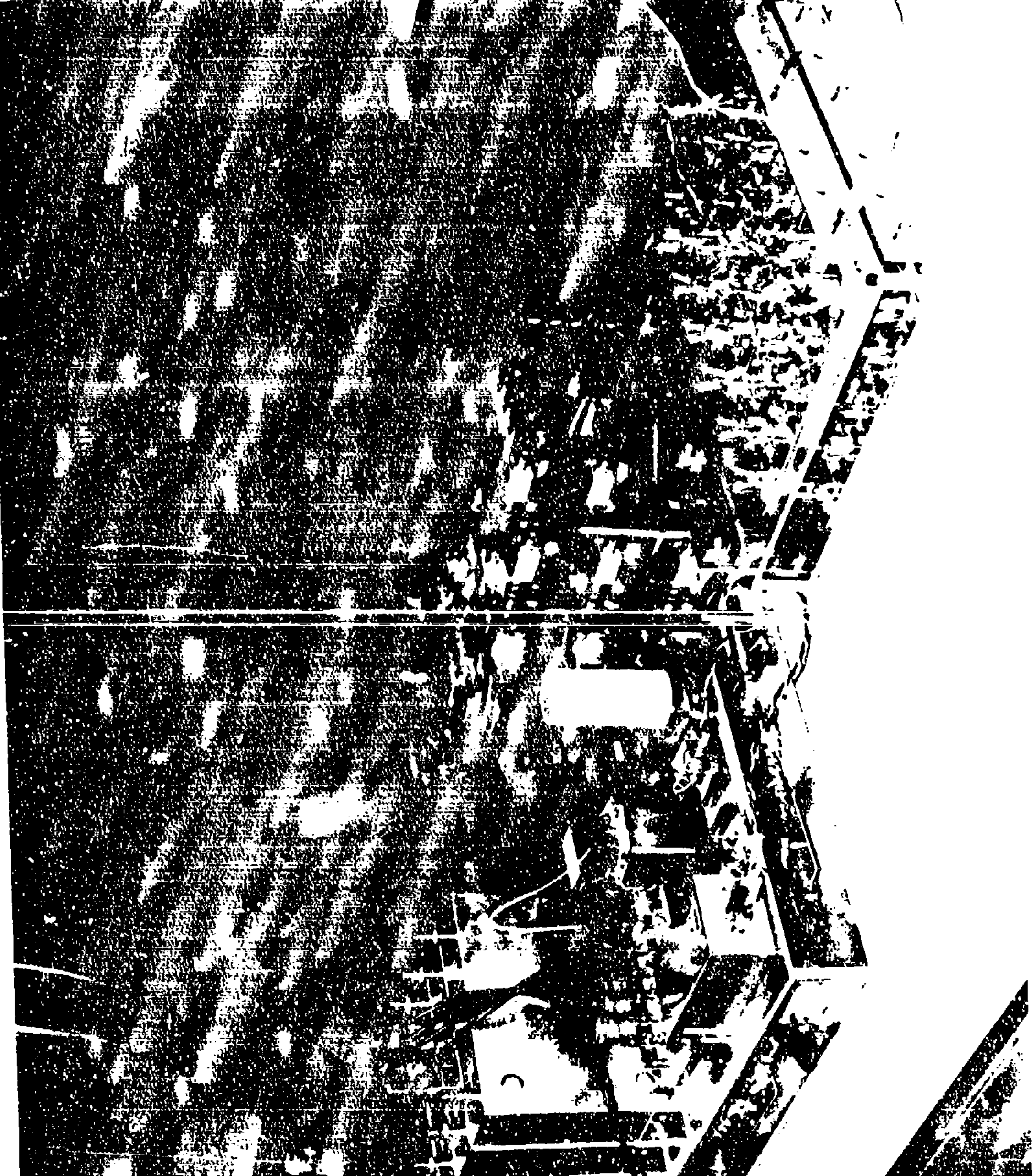


Figure 6. Experiment 7350 electronics chassis

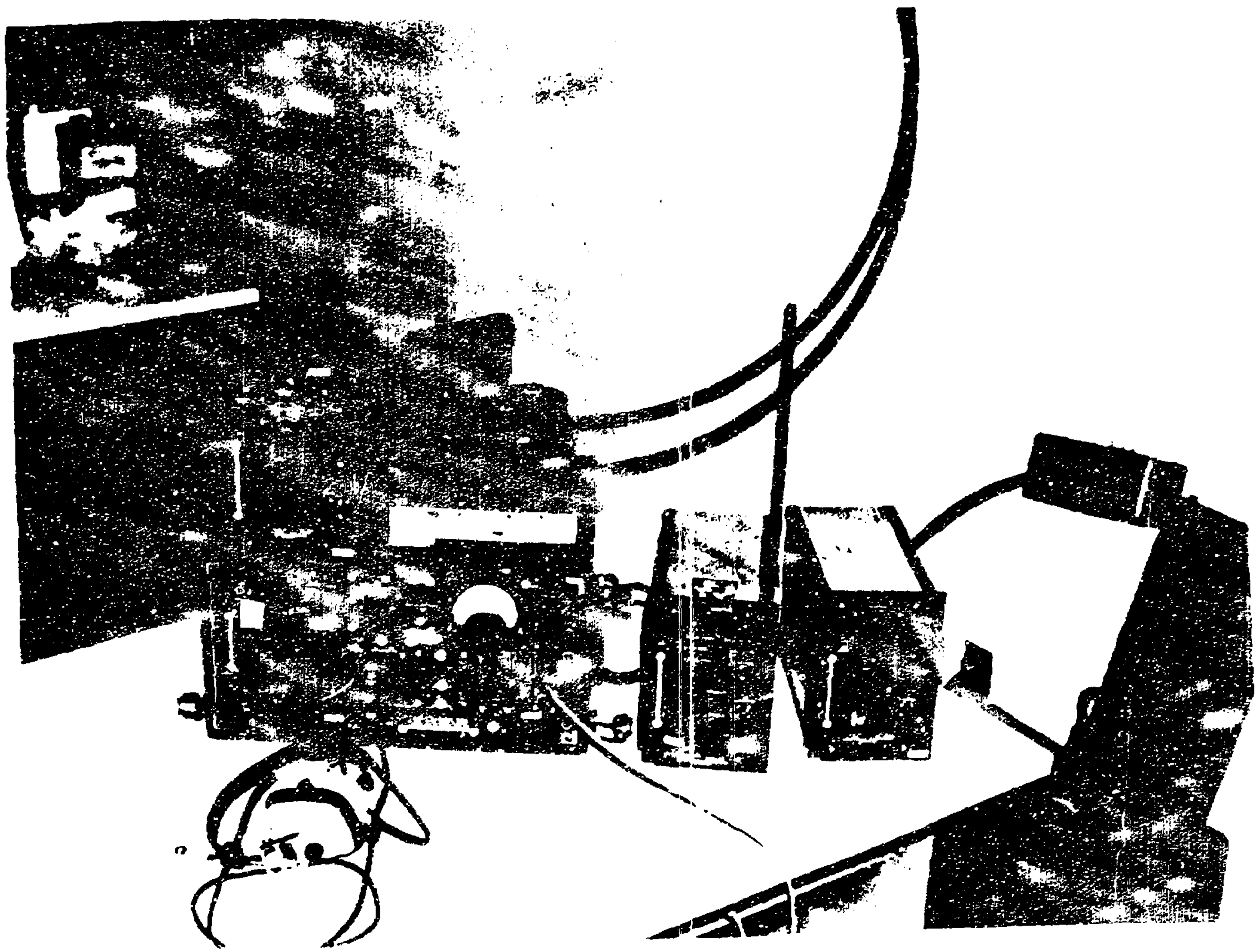


Figure 7. Empire NF-105 field strength meter

2-2 TECHNICAL SPECIFICATIONS.

Since four bands are outside the 600 kHz recorder bandwidth, it is necessary to heterodyne each with a local oscillator and mixer. This process is similar to the RF-IF conversion found in a superheterodyne receiver. In the 10-600 kHz bands, the actual frequency will be preserved. Thus, Cutler, ME on 17.8 kHz will appear at 17.8 kHz on its respective channel and Loran-C on 100 kHz will appear at 100 kHz, etc. In the other bands, however, since the FR must be mixed down to a baseband frequency of 10-600 KHz, all recorded signals will appear with a relative offset in the baseband. For instance, WWV on 2.5 MHz would be forun at 200 kHz on playback since it lies 200 kHz above 2.3 MHz, which is the bottom edge of the 2.3-2.9 MHz channel.

The 10-600 KHz bands use two electrostatically shielded and crossed-loop antennas, each one meter in diameter and made with eight turns. This type of antenna was chosen instead of an E-Field sensor because it reduces near-field pickup and provides an azimuthally directional pattern which can be used to cancel out the effects of the atmospheric noise.

Figure 8 taken from CCIR Report 322-2[1], shows that for Autumn between the hours of 1200-1600 UT in the southwestern United States, the value of the effective antenna noise factor in dB (Fam) is 40 dB at 1 MHz. Then from Figure 9 the corrected values of Fam can be determined for the frequencies of interest. These results are presented in Table 2.

[1]"Characteristics and Applications of Atmospheric Radio Noise Data", Report 322-2, International Telecommunications Union (ITU), International Radio Consultative Committee (CCIR), 1983

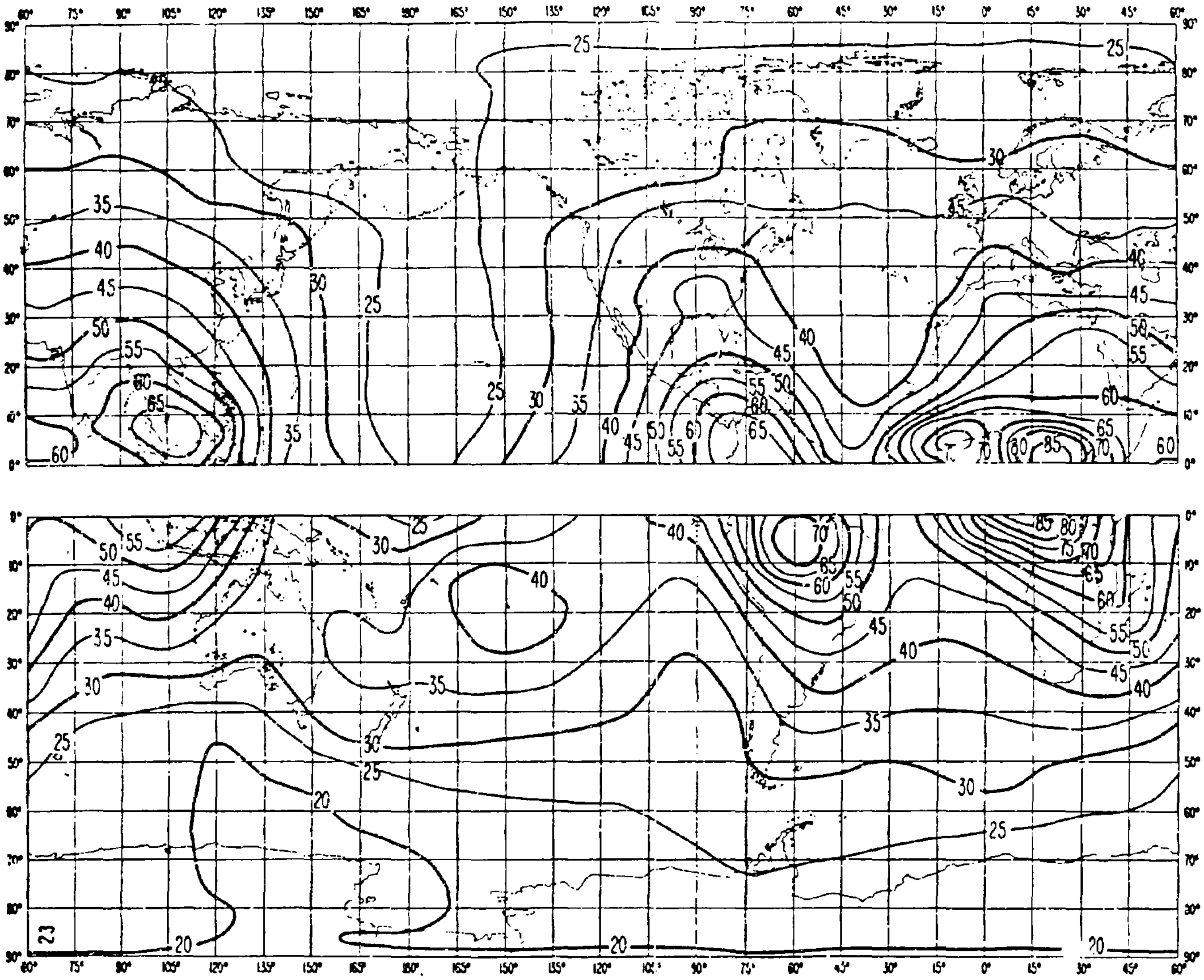


Figure 8. Expected values of atmospheric noise.

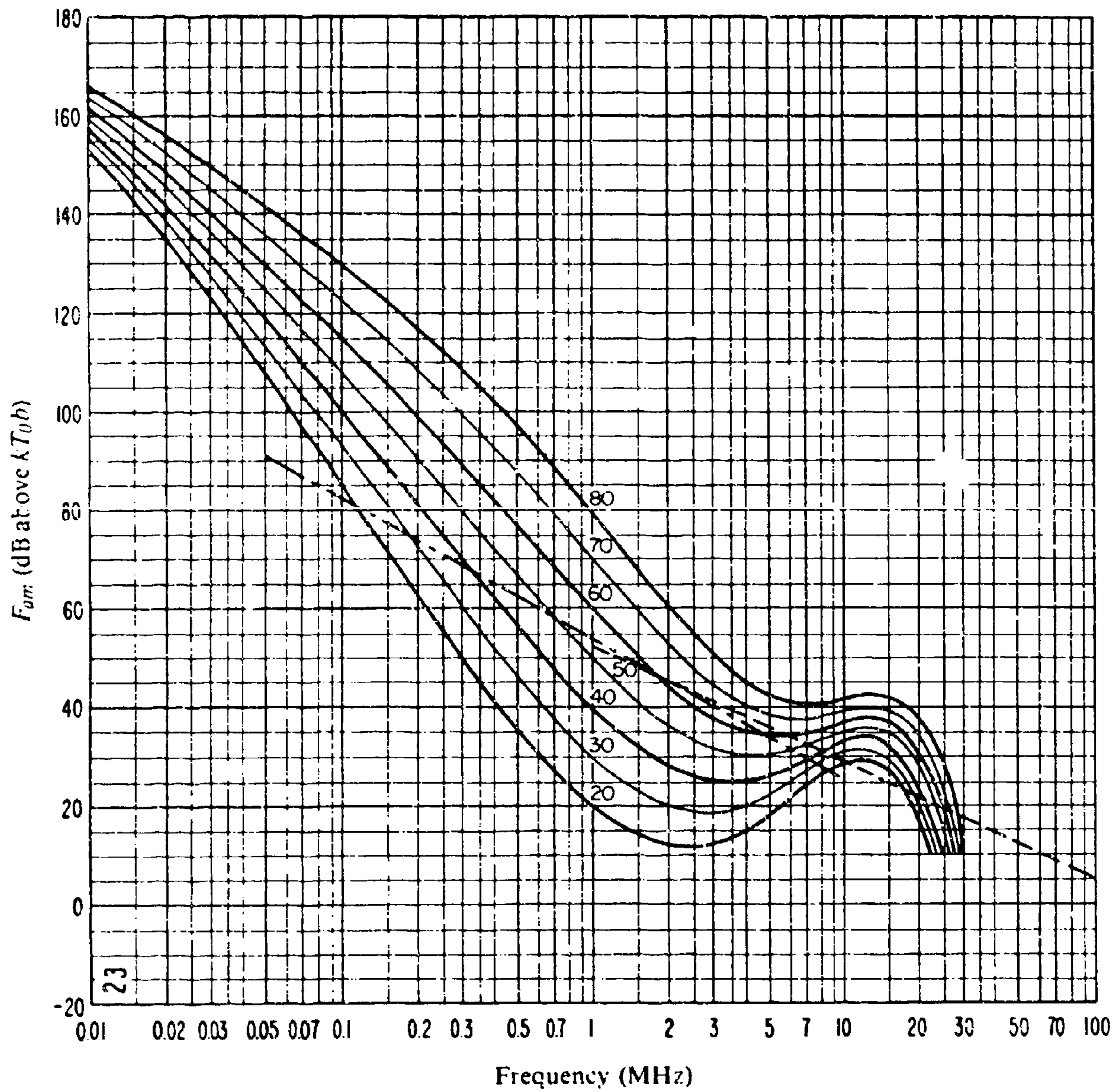


Figure 9. Variation of radio noise with frequency.

Table 2. Median atmospheric noise power as a function of frequency.

Fam = 157 dB	for f= 10 kHz
= 142 dB	for f= 20 kHz
= 115 dB	for f= 60 kHz
= 100 dB	for f= 100 kHz
= 70 dB	for f= 300 kHz
= 51 dB	for f= 600 kHz

The equivalent median (50%) vertical electric field strength (En) in dB referenced to 1μV/m in a 10 kHz bandwidth is given by Equation (2) in Reference 1.

$$En = Fam - 55.5 + 20 \log(\text{Frequency in MHz}) \tag{1}$$

Table 3 illustrates values for several frequencies in the range of interest.

Table 3. Median vertical E-field strength versus frequency.

En = 61.50 dB/1μV/m	@ 10 kHz
= 52.52 dB " "	@ 20 kHz
= 35.06 dB " "	@ 60 kHz
= 24.50 dB " "	@ 100 kHz
= 4.04 dB " "	@ 300 kHz
= -8.94 dB " "	@ 600 kHz

Figure 10 provides an upper decile (90%) correction to the median (50%) noise values. This means that the corrected values will only be exceeded 10 percent of the time for the 1200-1600 hour block. The resulting upper decile noise values are shown in Table 4.

Table 4. Upper decile (90%) E-field strength from 10-600KHz.

En	= 65.50 dB/uV/m	@	10 kHz
	= 61.52 dB " "	@	20 kHz
	= 50.06 dB " "	@	60 kHz
	= 41.00 dB " "	@	100 kHz
	= 21.74 dB " "	@	300 kHz
	= 8.26 dB " "	@	600 kHz

The voltage induced in a loop antenna is given by the following equation[2]

$$Vin = 2.094 * 10E\text{-}8 * F * E * A * n \tag{2}$$

where Vin - voltage at the loop antenna terminals,

F = frequency in Hz

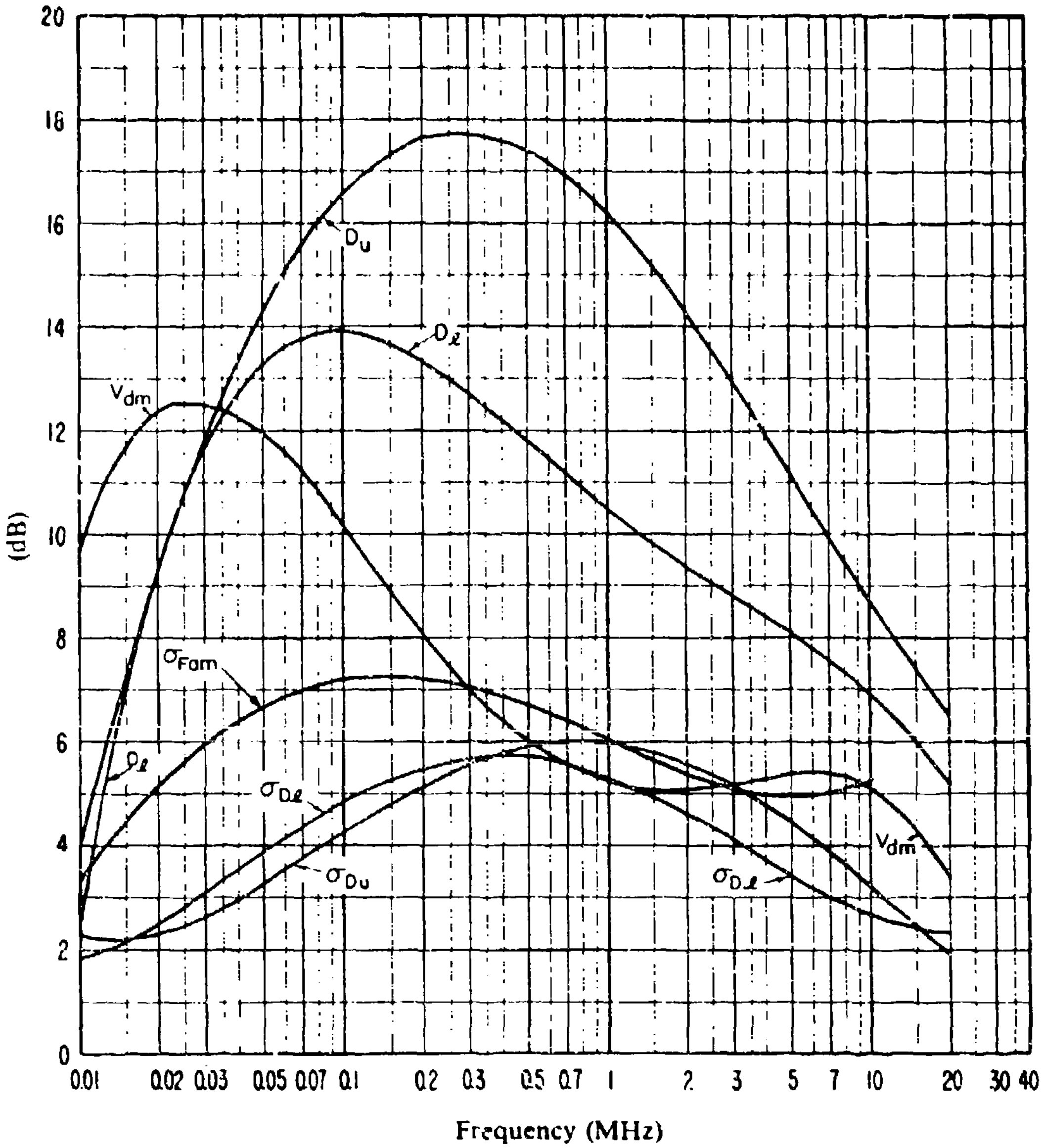
E = field of strength in V/m

A = area of loop in square meters

n = number of turns in the loop

For the predicted upper decile noise values, the output voltage at the loop terminals, assuming the loop lies in the plane of the noise, is presented in Table 4.

2 "Antenna Engineering Handbook", JASIK, McGraw-Hill, 1961



σ_{Fam} : Standard deviation of values of F_{am}
D_u : Ratio of upper decile to median value, F_{am}
σ_{Du} : Standard deviation of values of D_u
D_l : Ratio of median value, F_{am}, to lower decile
σ_{Dl} : Standard deviation of value of D_l
V_{dm} : Expected value of median deviation of average voltage.
The values shown are for a bandwidth of 200 Hz.

Figure 10. Data on noise variability and character.

Table 5. Predicted upper decile noise values.

Vin = 2.48 uV @ 10 kHz
= 3.13 uV @ 20 kHz
= 2.51 uV @ 60 kHz
= 1.48 uV @100 kHz
= 0.47 uV @300 kHz
= 0.29 uV @600 kHz

The detectable signal level threshold for the 10-600 kHz band channels was experimentally determined to be 0.18 uV (measured in 10 kHz bandwidth) at the input to the field-effect transistor stage, contained in loop housing.

By rearranging (2) the minimum detectable vertical electric field strength in a 10 kHz bandwidth is equal to:

$$\mathrm{MDF(V/m)} = \frac{0.18 \times 10E\text{-}6}{2.094 \times 10E\text{-}8\ F \times A \times n} \qquad (3)$$

Calculating the values for the bands under consideration, we find MDF levels as tabulated in Table 6.

Table 6. Calculated minimum detectable vertical E-field at loop antenna terminals.

MDF =	137.0 uV/m	= 42.73 dB/uV/m	@ 10 kHz
=	68.4 uV/m	= 36.70 dB/uV/m	@ 20 kHz
=	22.8 uV/m	= 27.16 dB/uV/m	@ 60 kHz
=	13.7 uV/m	= 22.73 dB/uV/m	@100 kHz
=	4.6 uV/m	- 13.26 dB/uV/m	@300 kHz
=	2.3 uV/m	= 7.23 dB/uV/m	@600 kHz

Therefore, by comparing Tables 4 and 6 it is evident that the loop antennas are atmospheric noise limited.

Accordingly, a method which allows separating the atmospheric noise from any event-produced noise was included in the design. This was achieved by orienting the crossed-loops so one was in the plane of the great circle path between GZ and the observation site for maximum response and the other positioned broadside or nulled on the GZ.

For the remaining channels, the minimum front-end input voltage required for a +10 dB SNR was experimentally determined and is presented in Table 7.

Table 7. Minimum front-end input voltage for +10 dB SNR.

Frequency (NHz)	Vmin (uV)
2.3 - 2.9	1.58
15.0 - 15.6	0.63
50.0 - 50.6	0.63
220.0 - 220.6	0.63

By using a different technique it is possible to calculate the values of the predicted noise recording system performance over the remaining frequency bands, shown in Table 8.

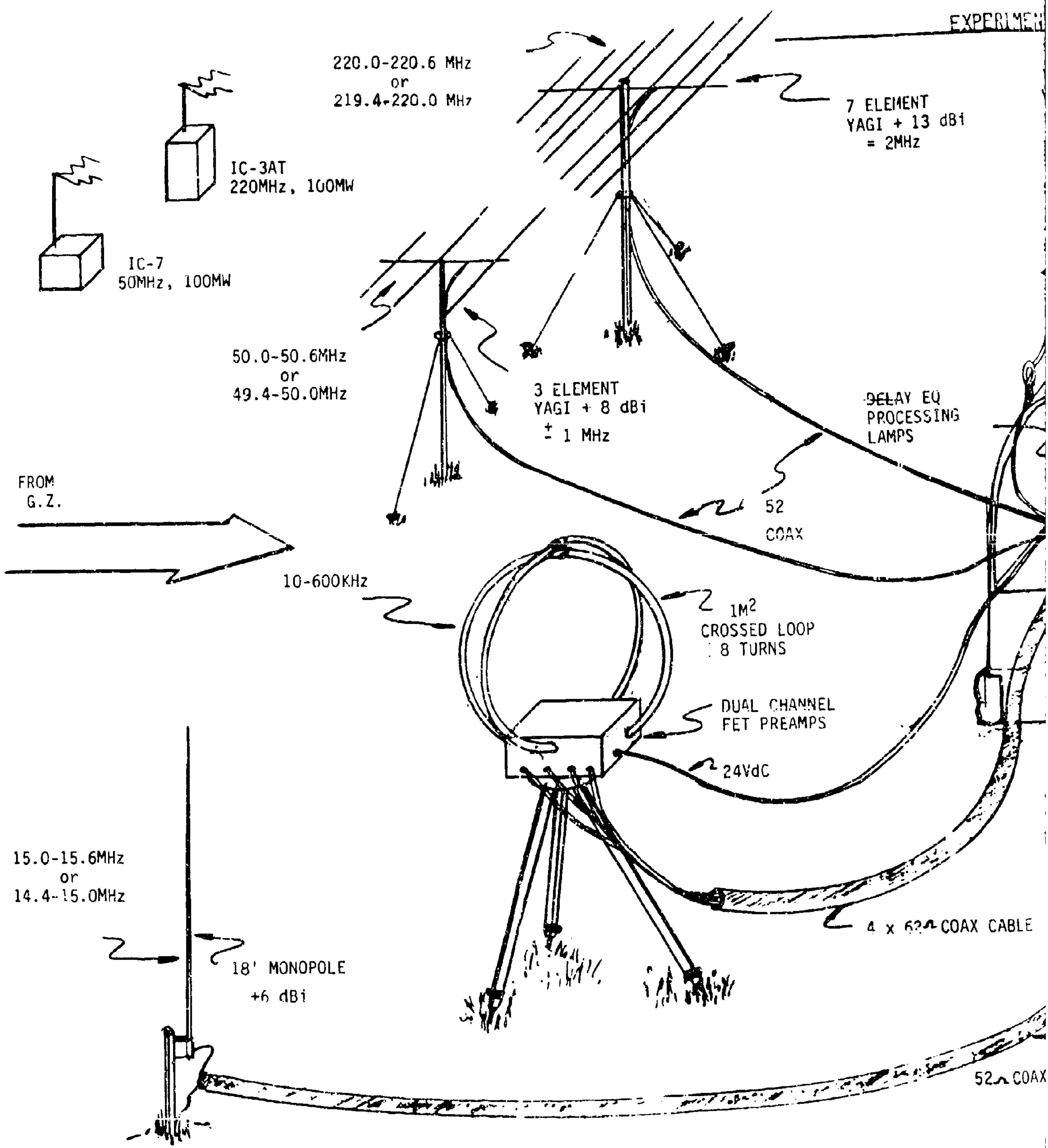
Table 8. Electrical performance of noise measuring system.

Frequency Range	Minimum Detectable E-Field (+10 dB SNR & 10 kHz B.W.)	Rise Time (uSec)	Dynamic Range (dB)	Group Delay (usec)
10.0 - 600.0 kHz	137.0 uV/m @ 10 kHz	0.7	70	Flat to 100
	2.3 uV/m @ 600 kHz			
2.3 - 2.9 MHz	3.2 uV/m	0.7	70	Flat to 100
15.0 - 15.6 MHz	1.1	0.7	70	Flat to 100
50.0 - 50.6 MHz	0.8 uV/m	0.7	70	Flat to 100
220.0 - 220.6 MHz	0.5 uV/m	0.7	70	Flat to 100

APPENDIX - A

NOISE RECORDING SYSTEM DRAWINGS

Detailed drawings of the noise recording system equipment are presented in Figures A-1 thru A-24.


EXPERIMEN
220.0-220.6 MHz
or
219.4-220.0 MHz
7 ELEMENT
YAGI + 13 dBi
= 2MHz
IC-3AT
220MHz, 100MW
IC-7
50MHz, 100MW
50.0-50.6MHz
or
49.4-50.0MHz
3 ELEMENT
YAGI + 8 dBi
± 1 MHz
~~DELAY~~ EQ
PROCESSING
LAMPS
FROM
G.Z.
52
COAX
10-600KHz
1M2
CROSSED LOOP
8 TURNS
DUAL CHANNEL
FET PREAMPS
24VdC
15.0-15.6MHz
or
14.4-15.0MHz
18' MONOPOLE
+6 dBi
4 x 62Ω COAX CABLE
52Ω COAX

EXPERIMENT 7360 PHYSICAL CONFIGURATION

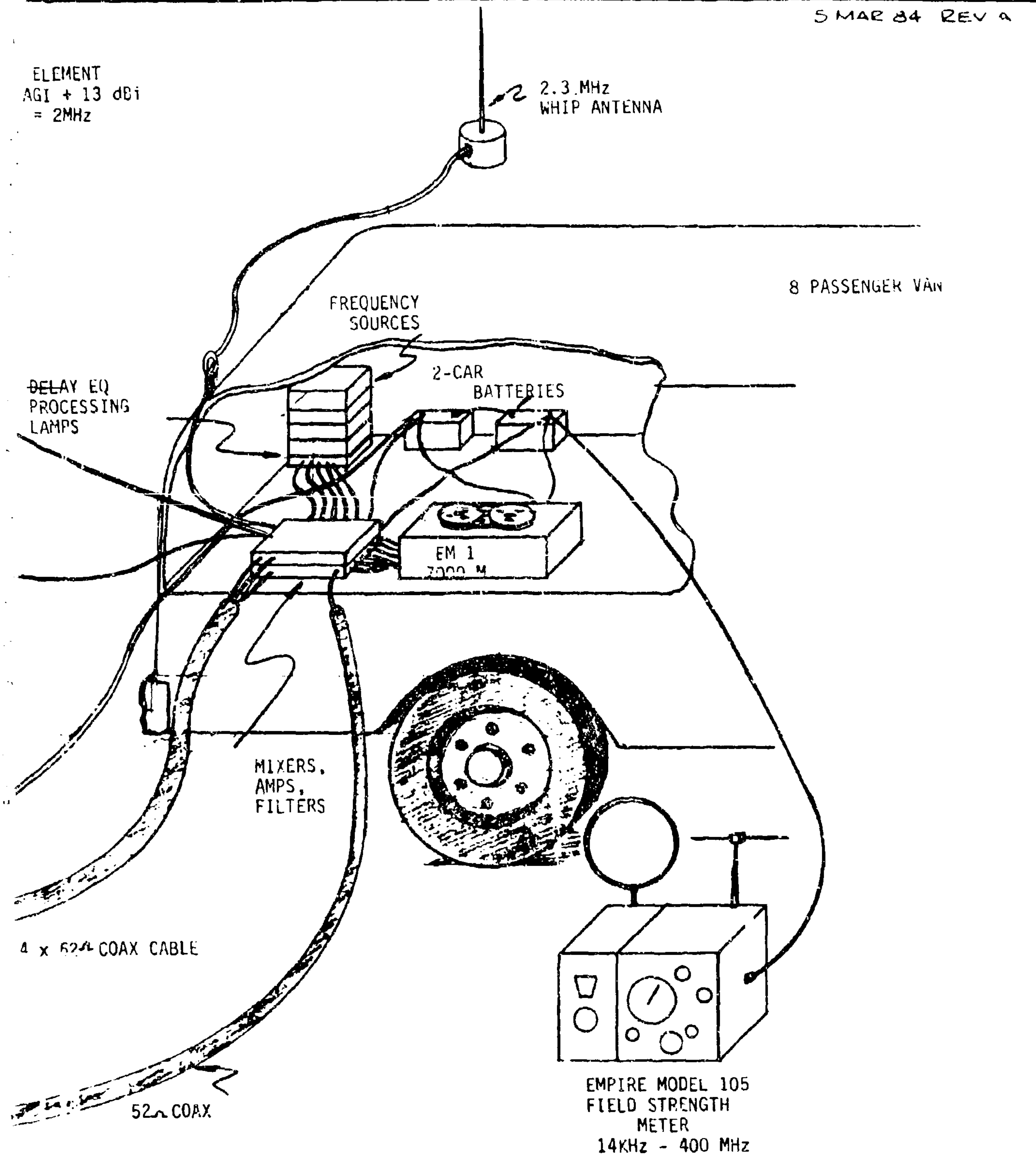


Figure A-1. Physical Configuration (deployed).

2

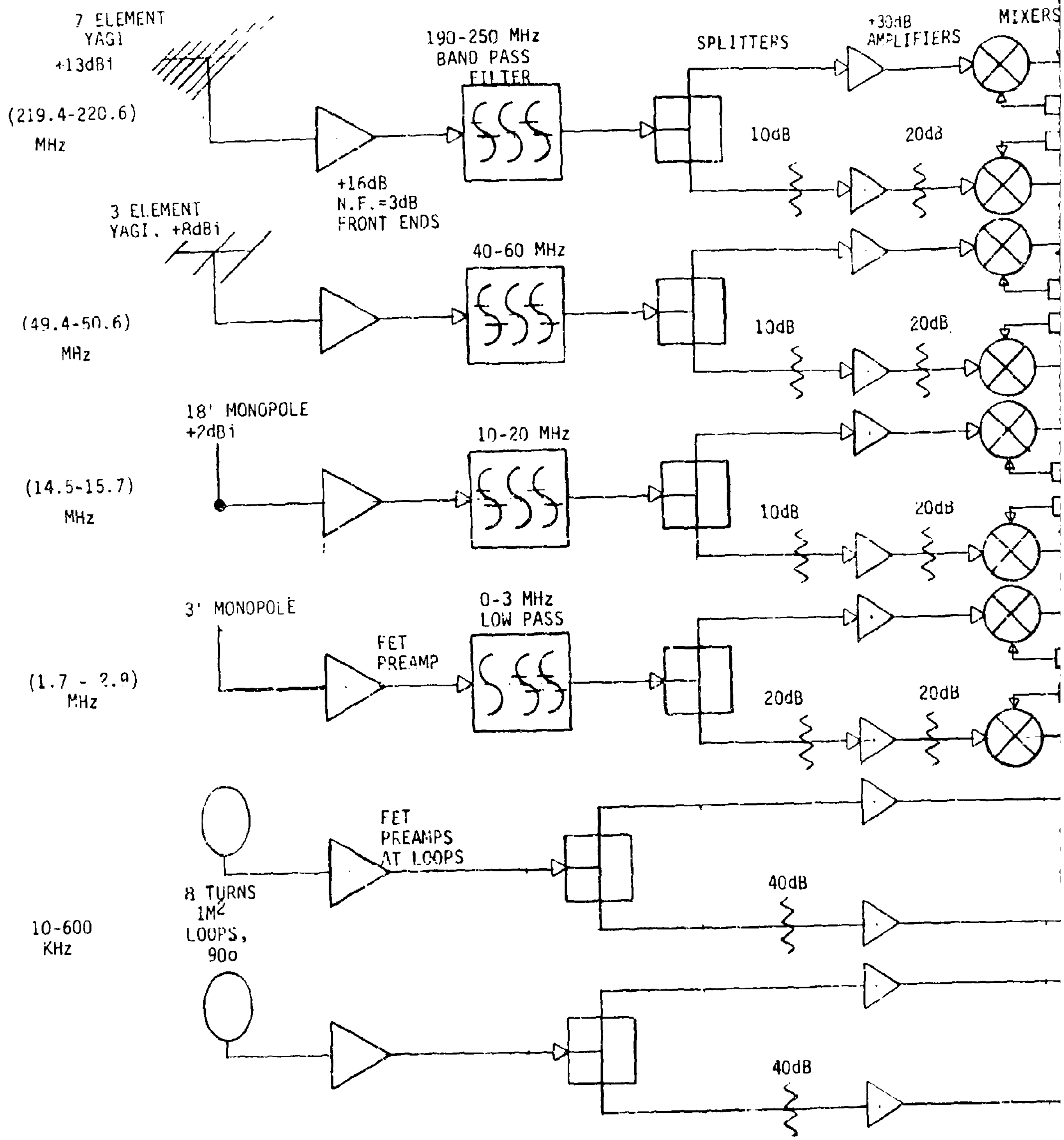
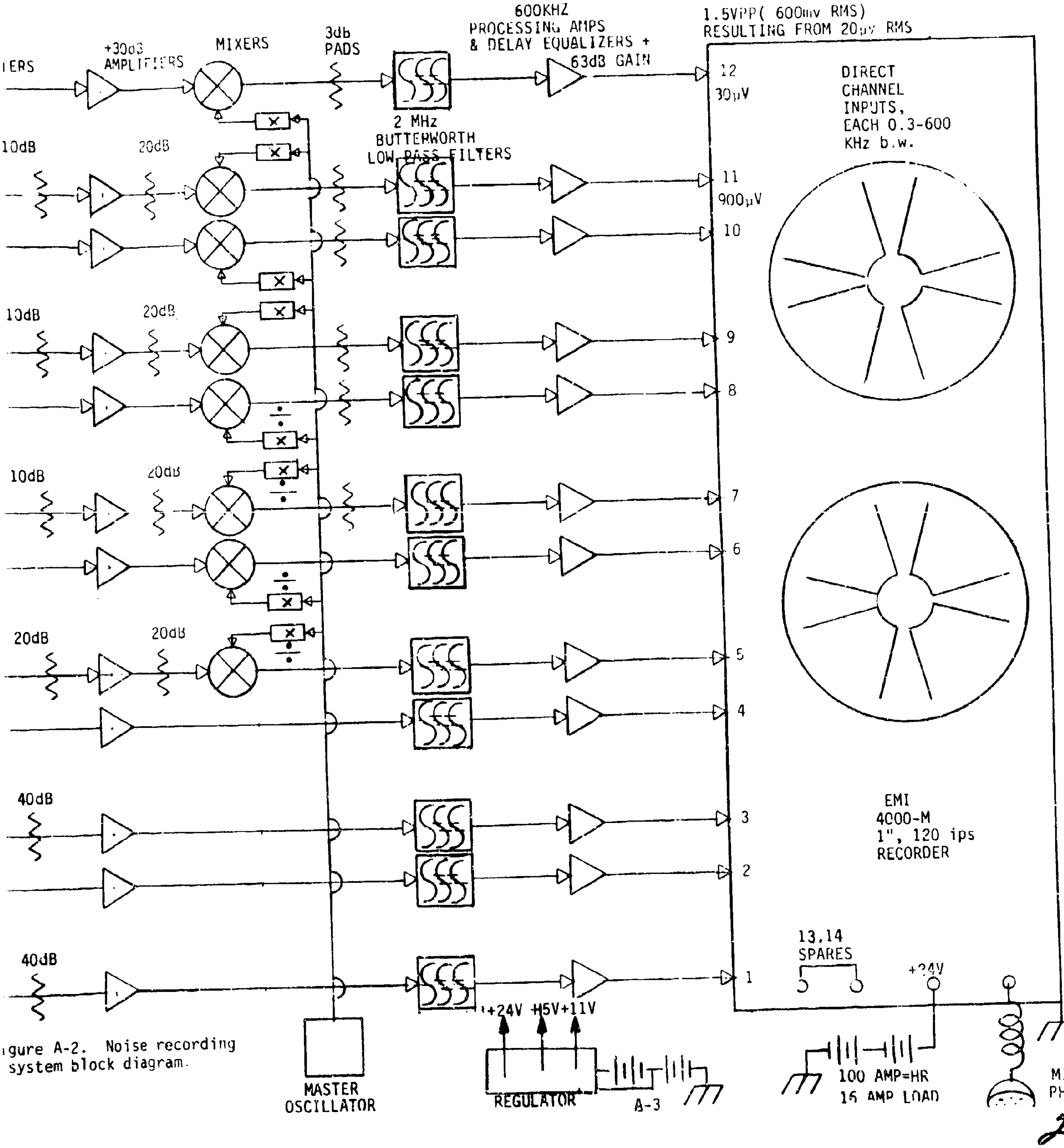


Figure A-2. Noise recording system block diagram.

EXPERIMENT 7360 BLOCK DIAGRAM 5 Mar 84 Rev. A



igure A-2. Noise recording system block diagram.

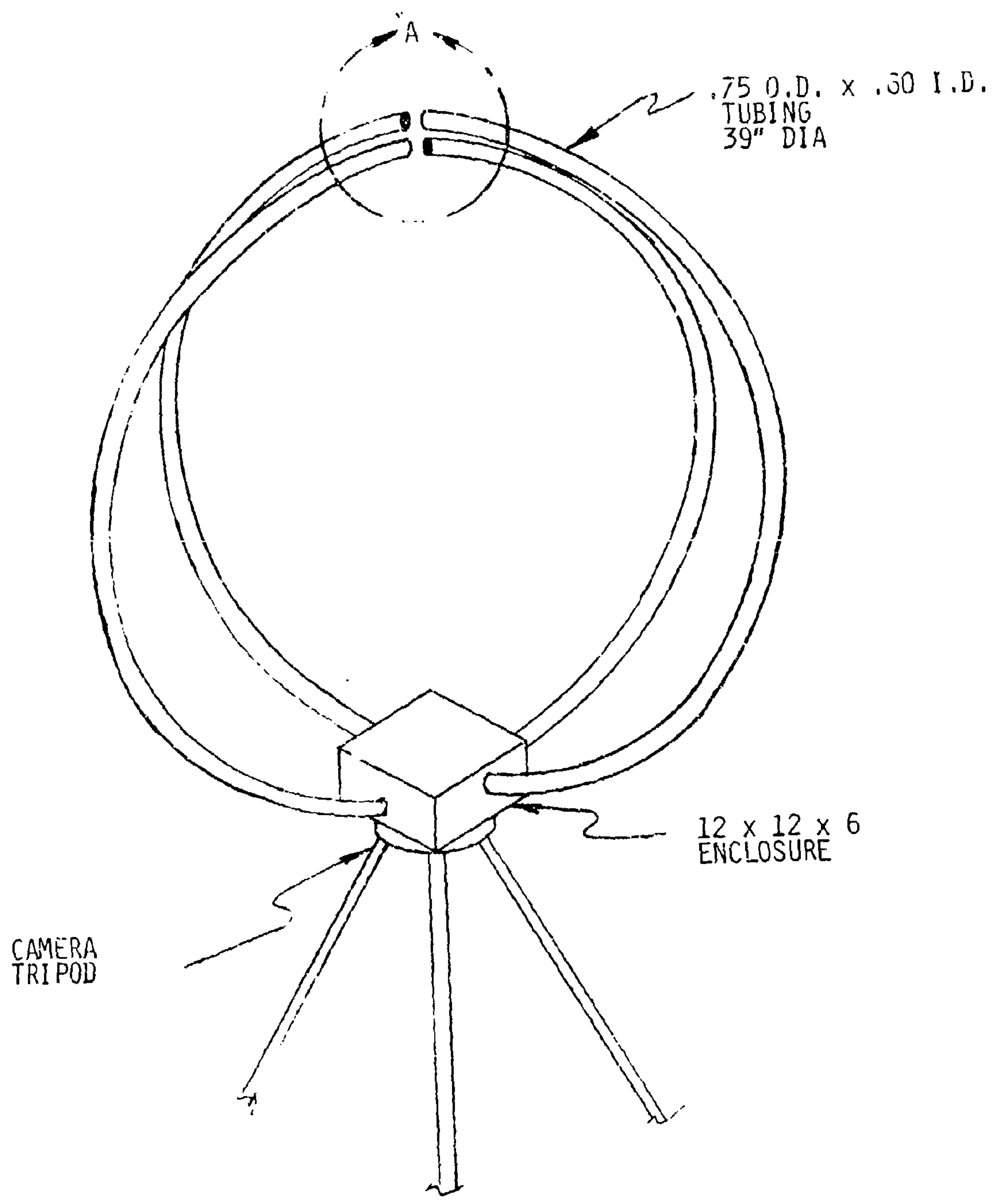
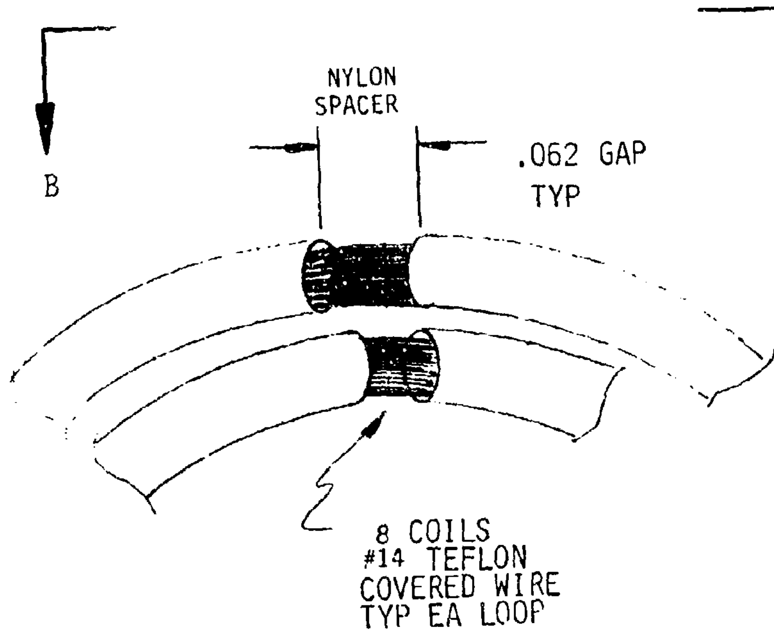


Figure A-3. 600 kHz crossed loop antenna



DETAIL A

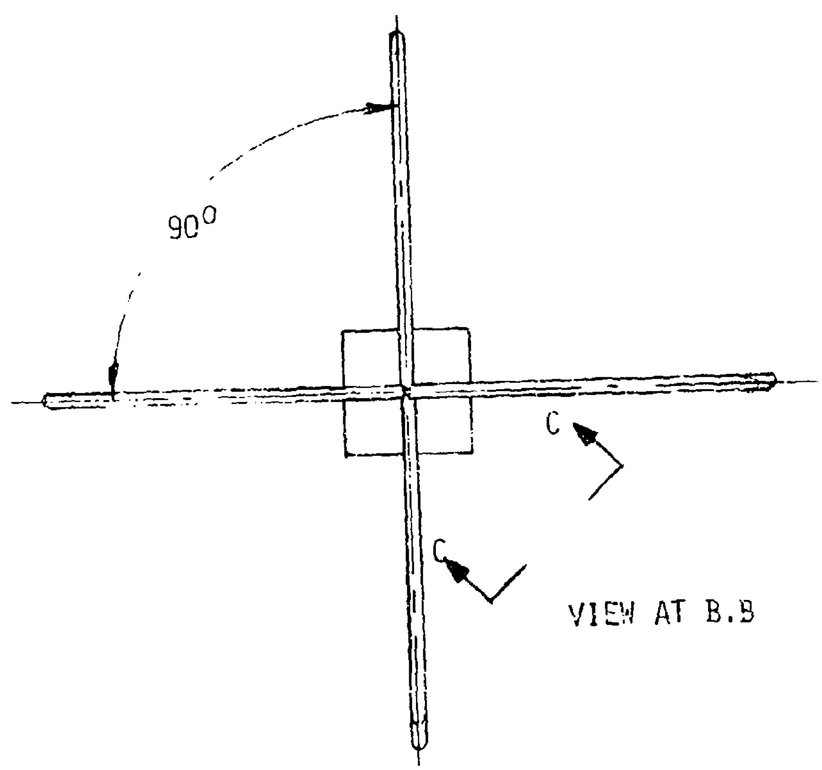
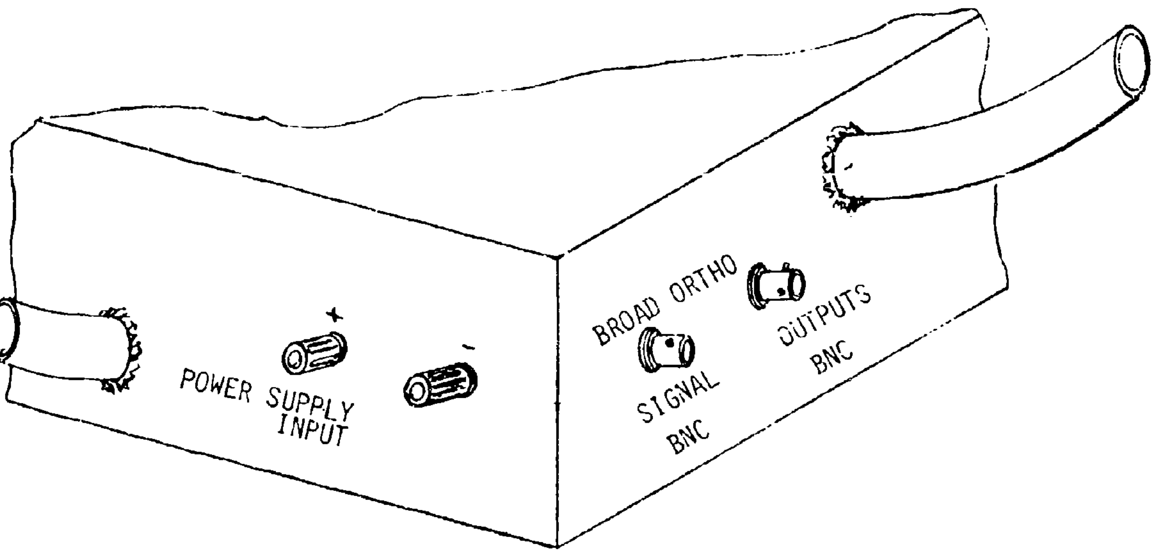


Figure A-4. Loop antenna section B-B.



VIEW AT C-C

Figure A-5. Loop antenna section C-C.

ASSEMBLY PICT

VHF

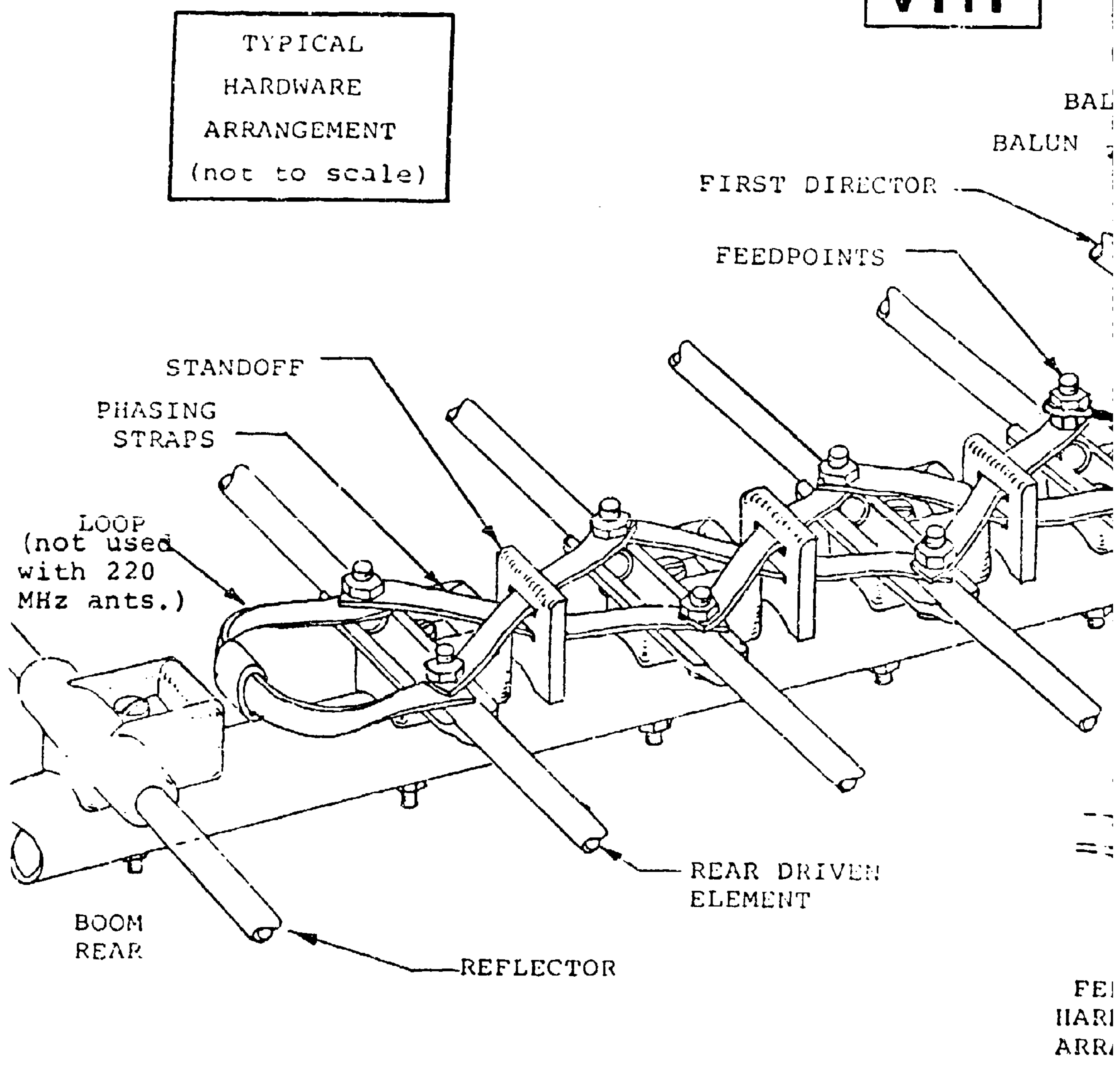
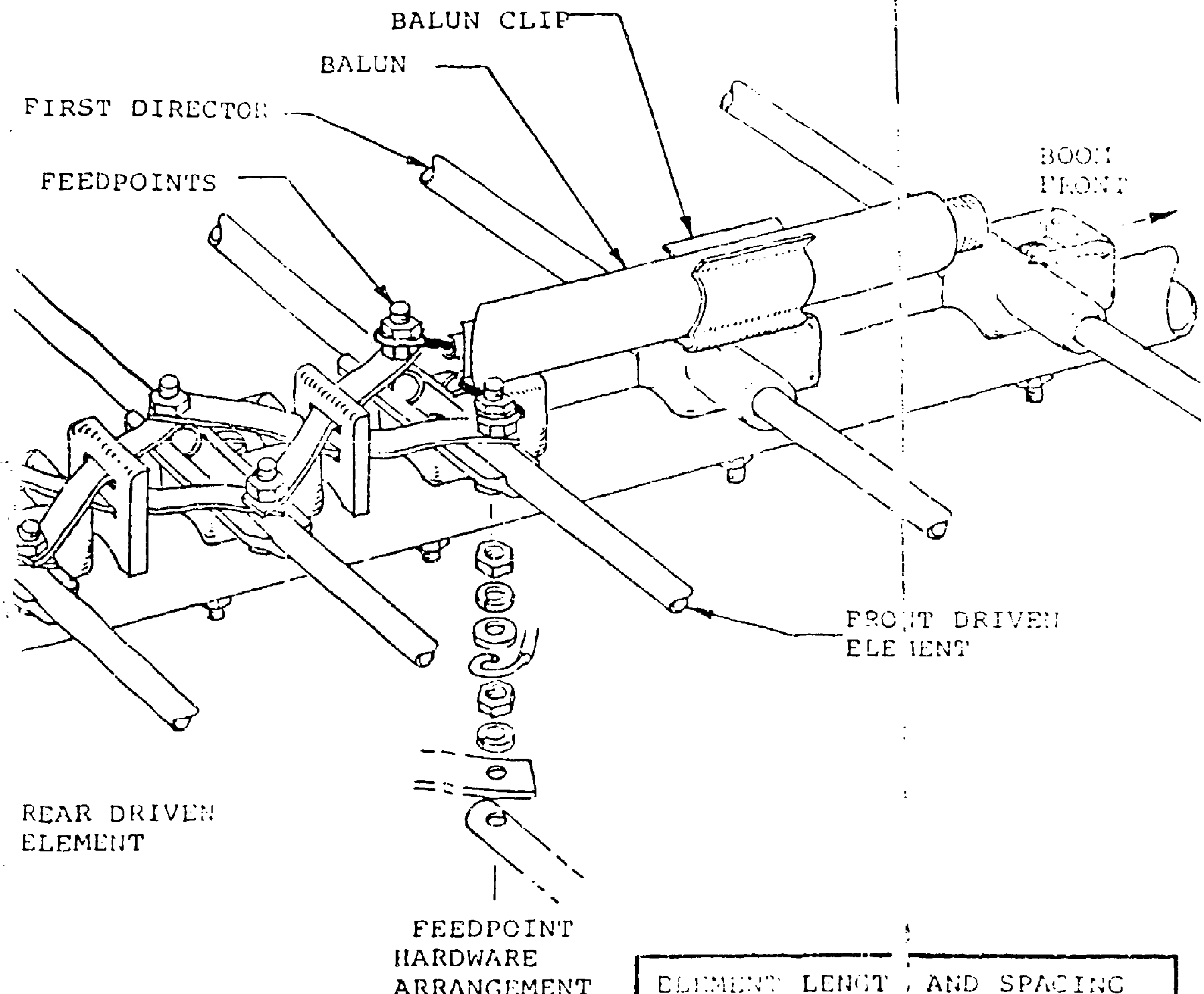


Figure A-6. 220 MHz horizontal yagi.

SEMBLY PICTORIAL

VHF



ELEMENT LENGTH AND SPACING WILL VARY WITH SPECIFIC ANTENNA MODEL. SEE DIMENSION SHEET SUPPLIED WITH ANTENNA.

2

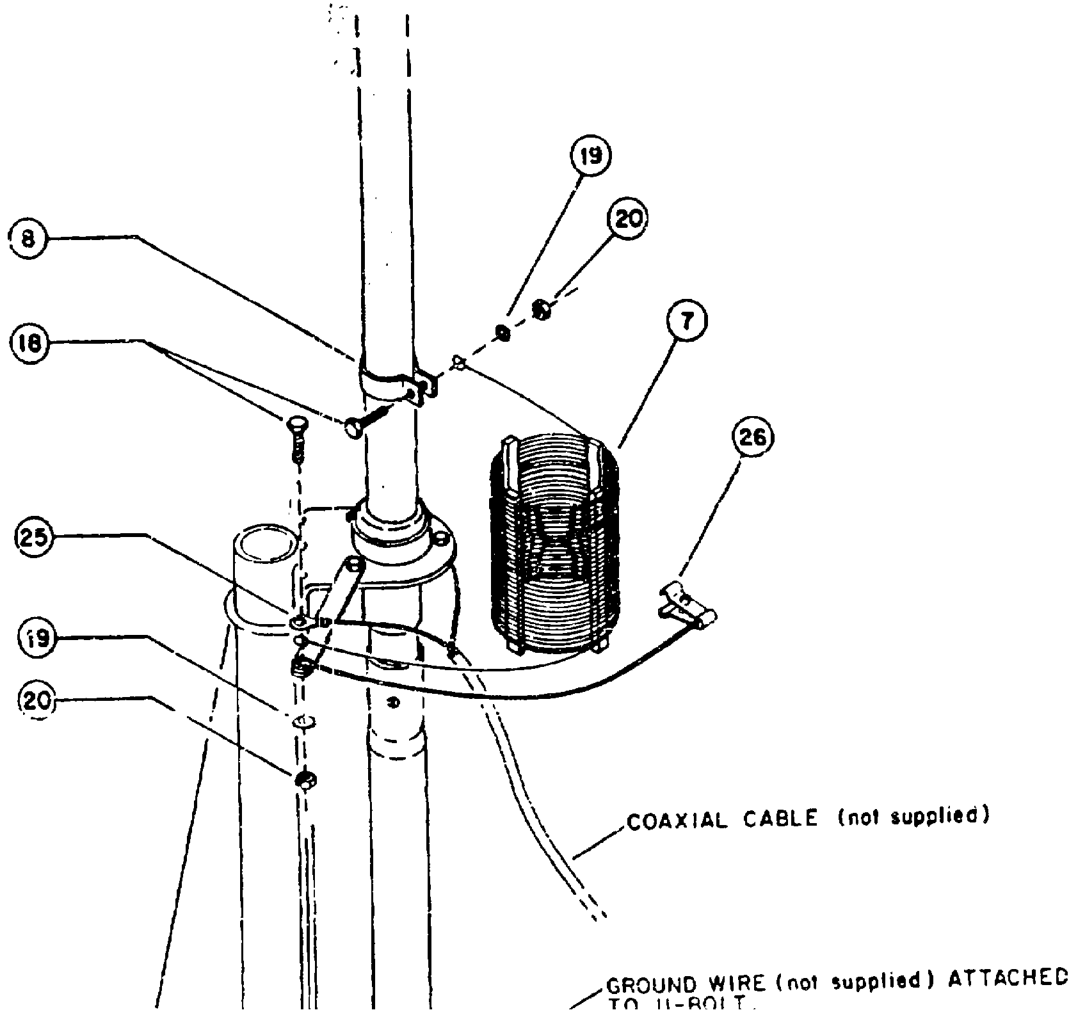
Select the M3 section (¾" x 53½") and slip the end with the smallest hole into the M2 section. Align the holes and fasten with two #8 screws (item 13)

Select the M4 section (⅝" x 53¼") and slip the end with the smallest hole into the M3 section. Align the holes and fasten with two #8 screws (item 13)

Select the M5 section (7/16" x 54") and slip the drilled end into the M4 section. Align the holes and fasten with a #10-24 x 1" bolt, nut, and lockwasher. (item 15, 16, and 17)

Place a 7/16" caplug on the end of the antenna.

AO-1935-C-005



Item No.	Description
7	Coil, inductor
8	Clamp, 7/8"
18	Bolt, 1/4"-20 x 1", hex head
19	Lockwasher, 1/4", internal
20	Nut, 1/4"-20, hex
21	U-bolt, 5/16" x 1 5/8" x 2 1/4"
22	Lockwasher, 5/16", split
23	Nut, 5/16"-16, hex
25	Solder lug, 1/4" ring
26	Assembly, inductor clip

8 Clamp, 7/8
18 Bolt, 1/4"-20 x 1", hex head
19 Lockwasher, 1/4", internal
20 Nut, 1/4"-20, hex
21 U-bolt, 5/16" x 1 5/8" x 2 1/4"
22 Lockwasher, 5/16", split
23 Nut, 5/16"-18, hex
25 Solder lug, 1/4" ring
26 Assembly, inductor clip

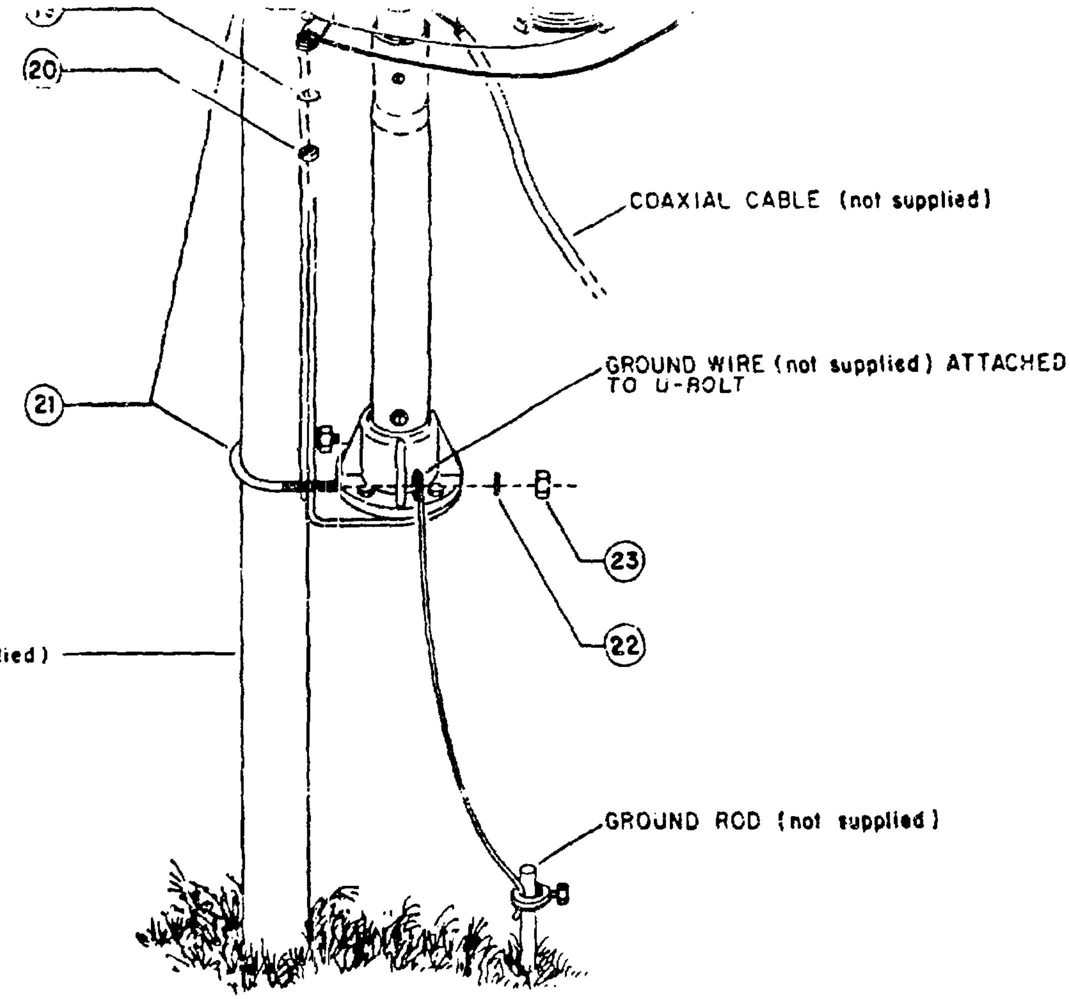
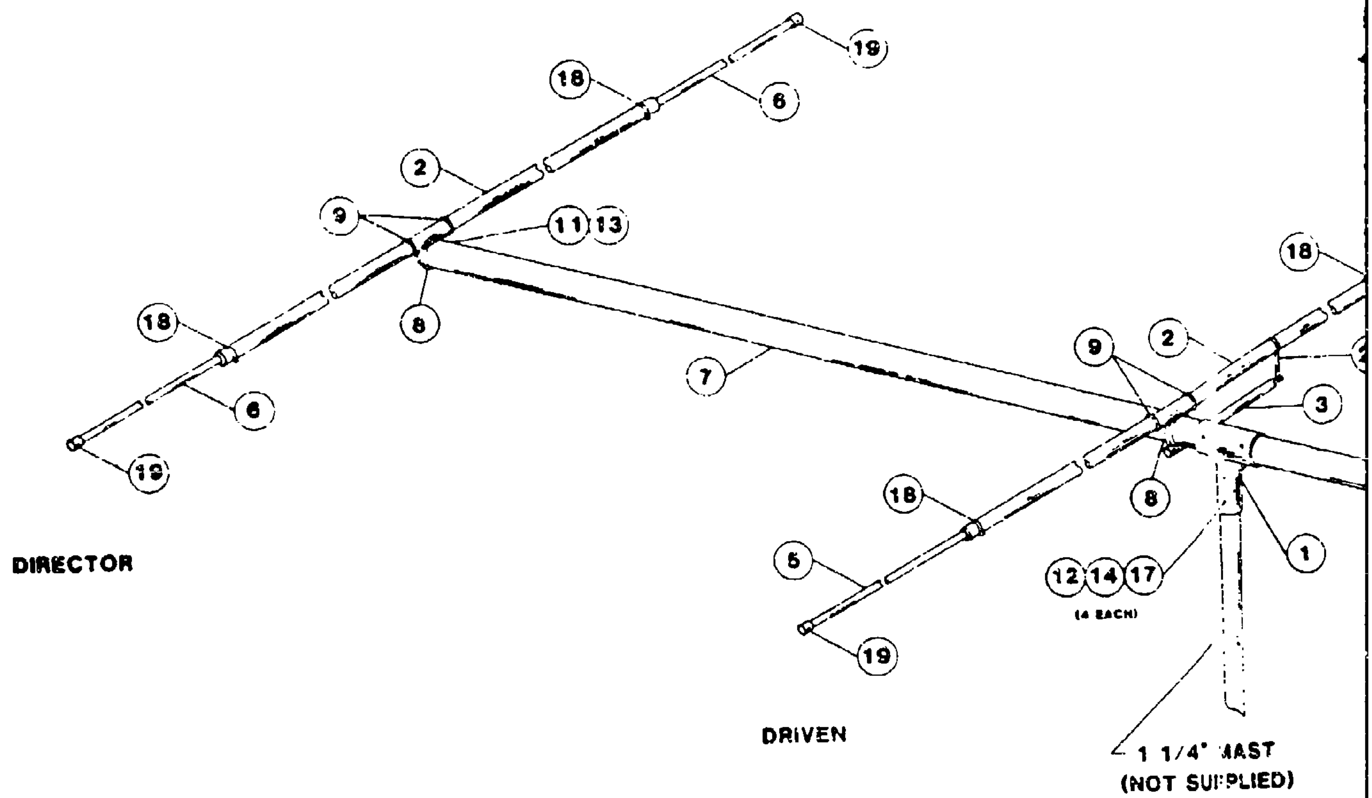


Figure A-7. 15 mHz vertical monopole.

2



19
18
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DIRECTOR
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12 14 17
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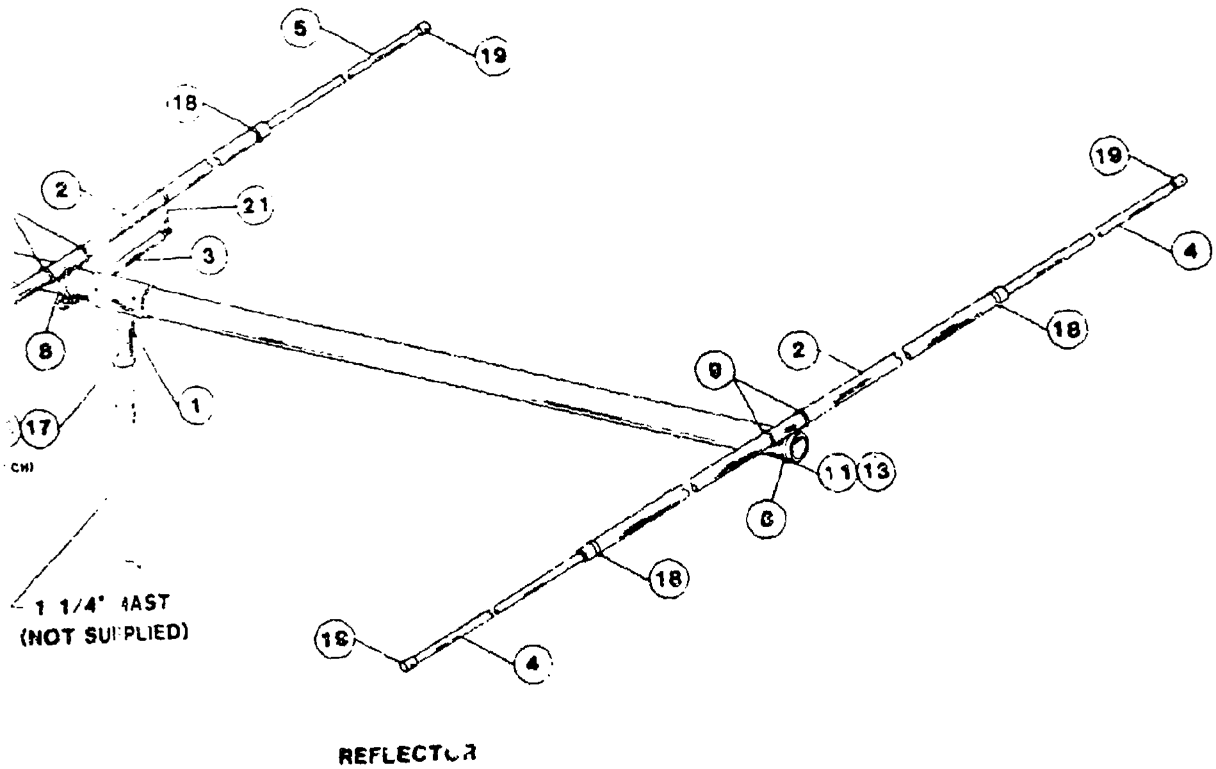


Figure A-8. 50 mHz horizontal yagi.

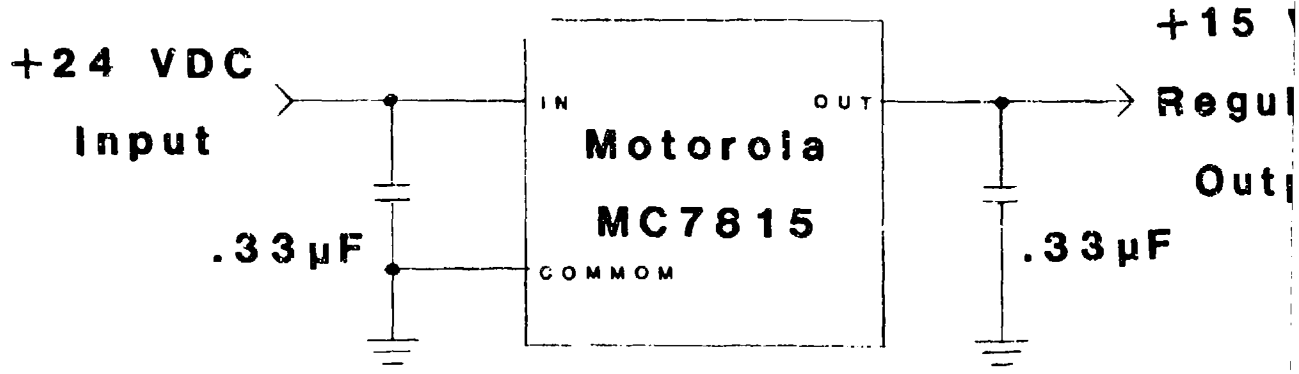


Figure A-9. Voltage regulator
15 VDC.

G6	G5	G4	G3	G2	G1	ITEM	SIZE
QTY PER ASSY							

NEXT ASSY	USED ON
APPLICATION	

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES
.XX DECIMAL ± — .XXX DECIMAL ± —
ANGLES ± — SURFACE QUAL — √ MAX

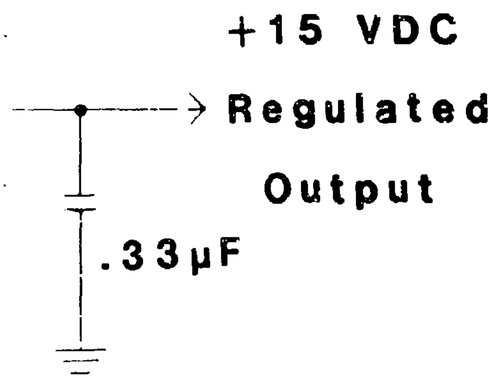
MFG

CONT NO.

DRFTG: DR D. Van; APPD; CHK

ENGRG: DEV; E/M; PROJ

REVISIONS				
ZONE	LTR	DESCRIPTION	DATE	APPROVED



3	G2	G1	ITEM	SIZE	PART NUMBER	DESCRIPTION

ASSY

PARTS LIST

...E SPECIFIED
... IN INCHES
...CES
XX DECIMAL
± ~
...FACE QUAL
~ √ MAX

CONT NO.

DRFTG DR D. Van Dusen DATE 15 Feb 83
APPD
CHK

ENGRG DEV
E/M
PROJ D. Rogers 15 Feb 84

RADANT SYSTEMS, INC.
255 HUDSON ROAD
STOW, MASSACHUSETTS
(617) 562-3866

Voltage Regulator
15 VDC

SIZE	CODE IDENT	DRAWING NO.
B		-592

SCALE — SHEET 1 OF 1

 DO NOT SCALE PRINT

2

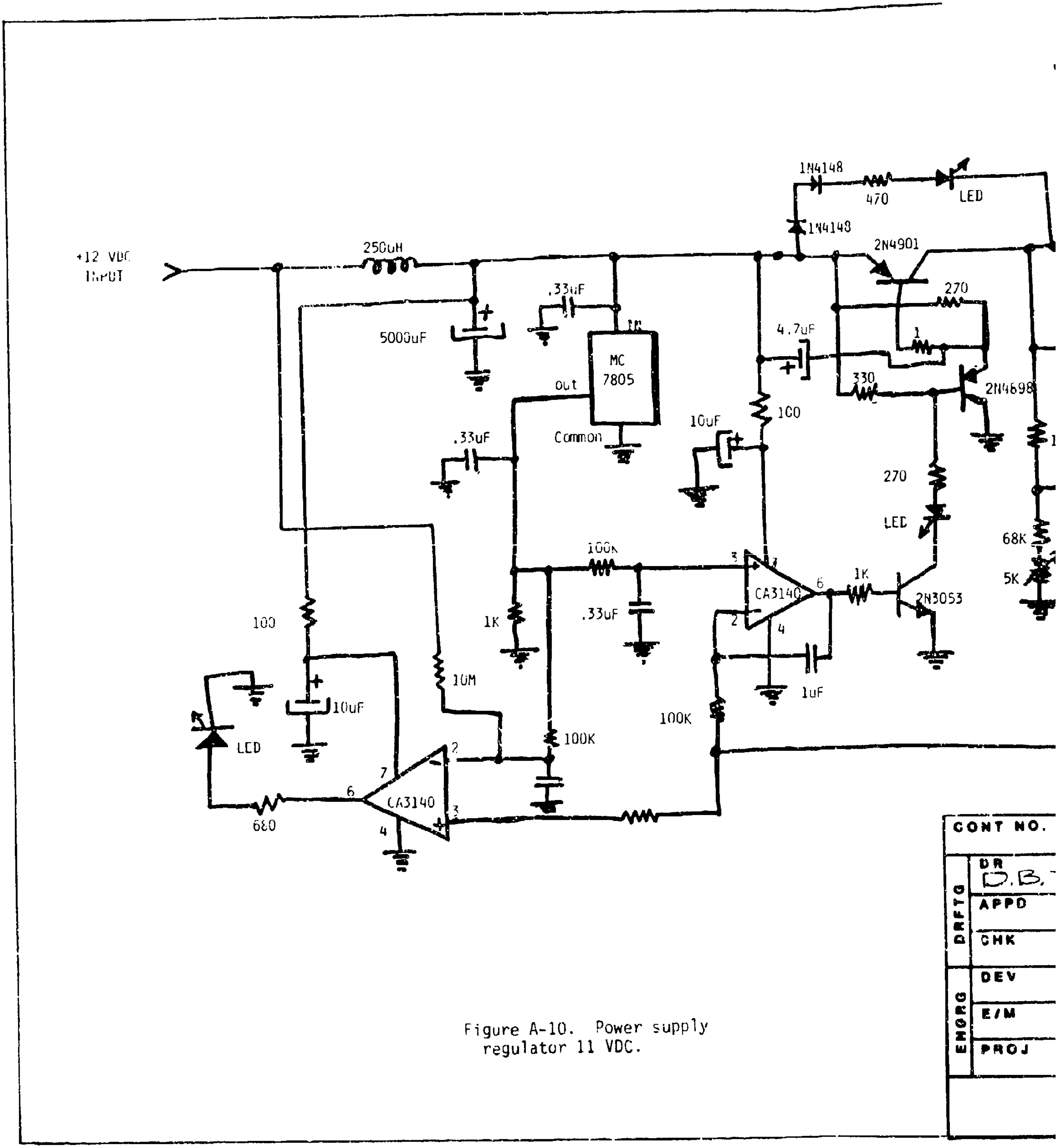
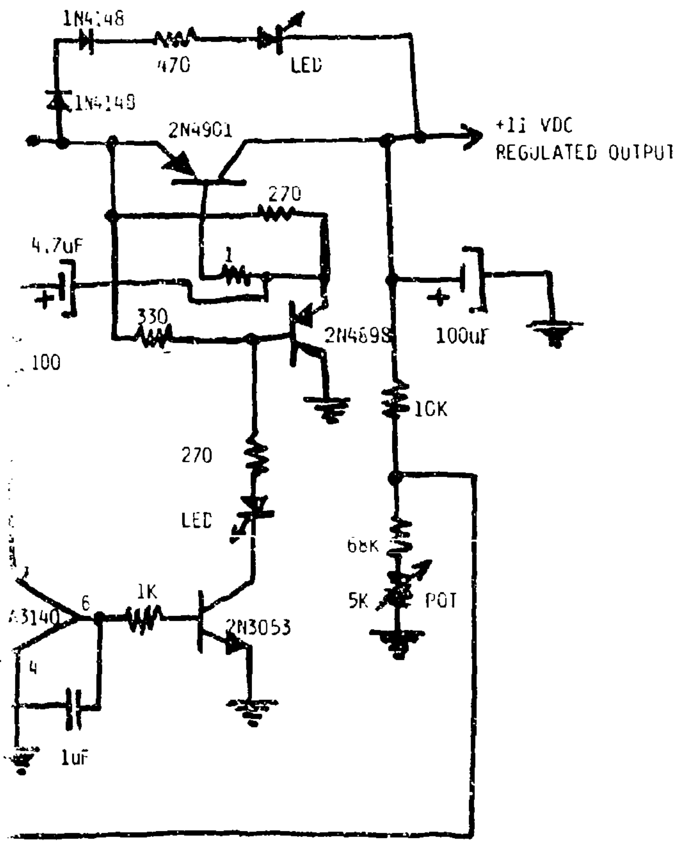


Figure A-10. Power supply regulator 11 VDC.



CONT NO.		RADANT SYSTEMS, INC.	255 HUDSON ROAD STOW, MASSACHUSETTS (617) 562-3866
DRFTG	DR D.B. TALBOT DATE 26 JUL 83	POWER SUPPLY REGULATOR 11VDC	
	APPD		
	CHK		
ENGRG	DEV	SIZE B	CODE IDENT / DRAWING NO. -581
	E/M		
	PROJ		
		SCALE	SHEET 1 OF 1

DO NOT SCALE PRINT

2

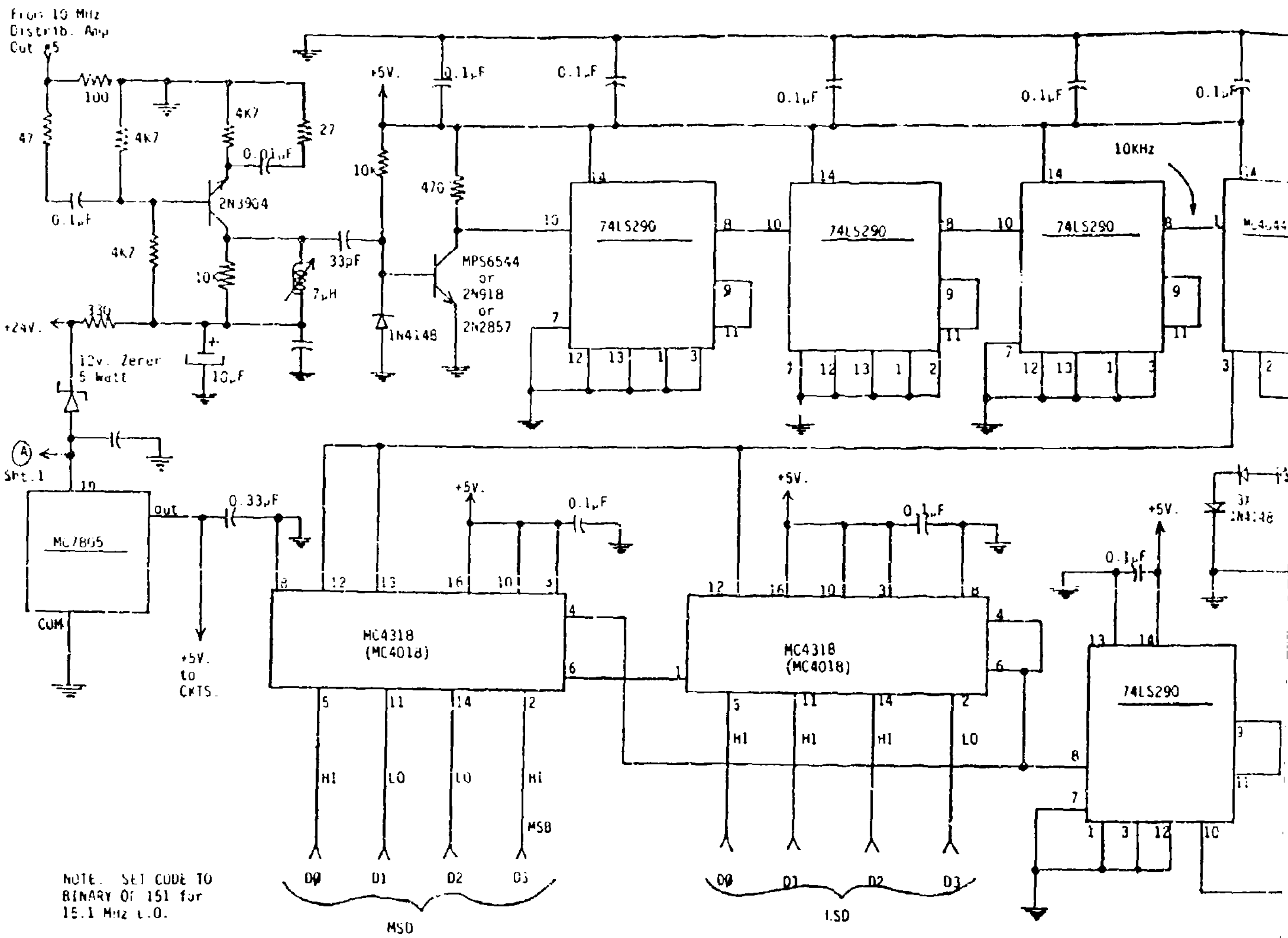


Figure A-11. 15.1 MHz local oscillator

CONT NO.

DRFTG

DR D.E.T.

APPD

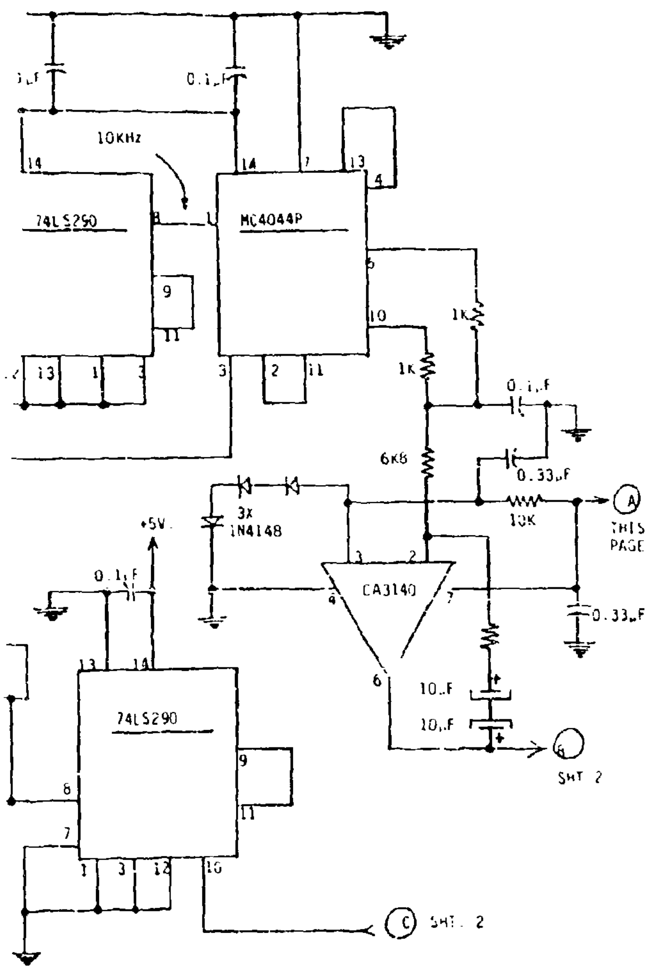
CHK

ENGRG

DEV

E/M

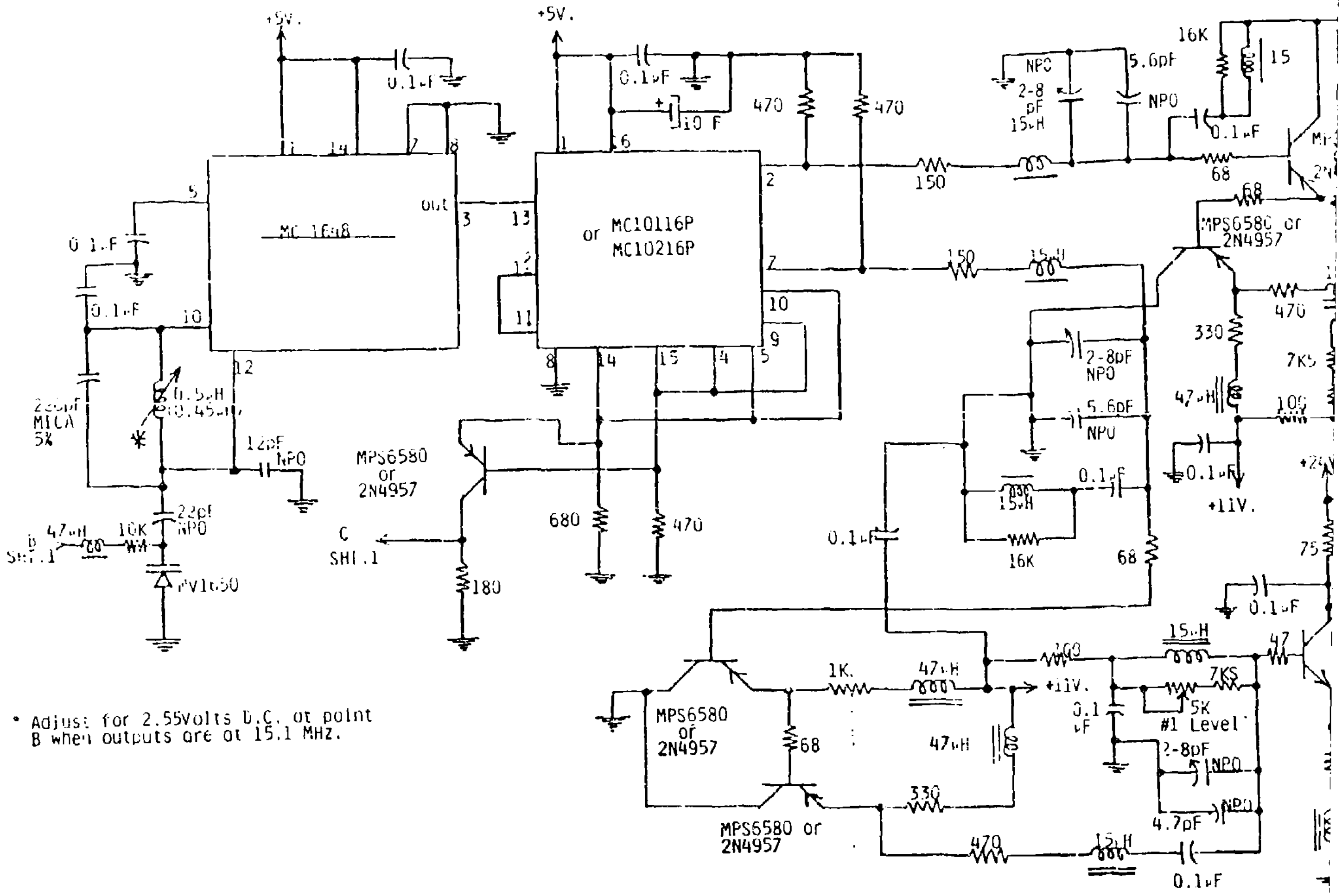
PROJ



CONT NO.	RADANT SYSTEMS, INC. 255 HUDSON ROAD STOW, MASSACHUSETTS (617) 562-3866
DRFTG DR D.B. TALBOT DATE JUL 26, 83	
APPD	**LOCAL OSCILLATOR**
CHK	**15.1 MHz**
ENGRG DEV	
E/M	SIZE **B** / CODE IDENT / DRAWING NO. **-580**
PROJ	SCALE — / SHEET 1 OF 2

A-12 DO NOT SCALE PRINT

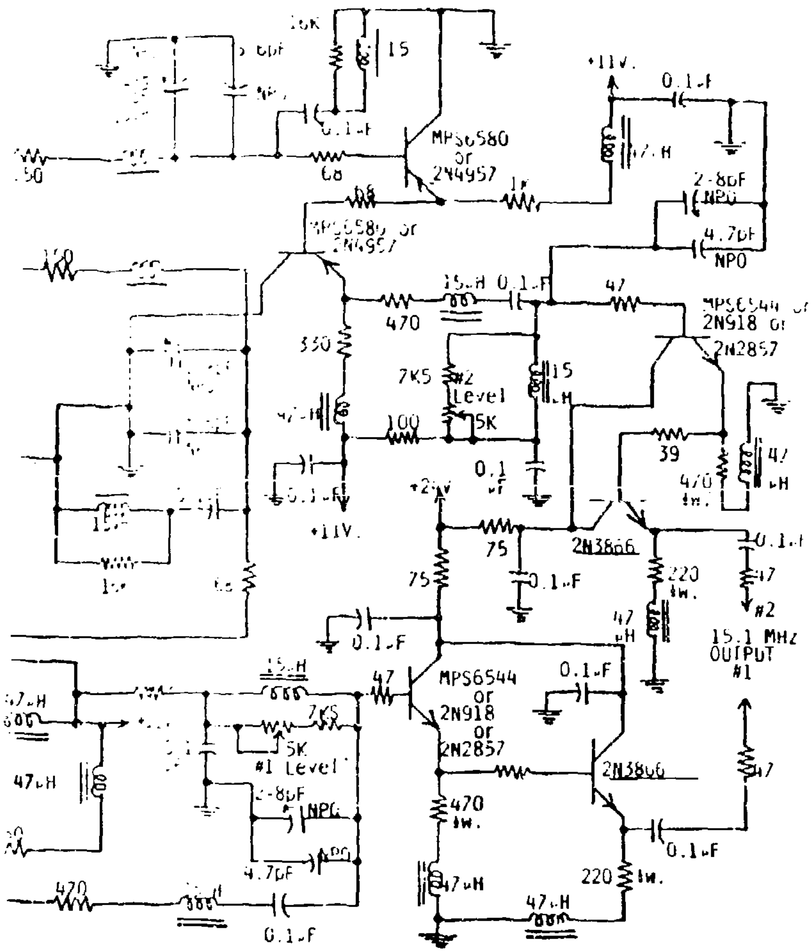
2



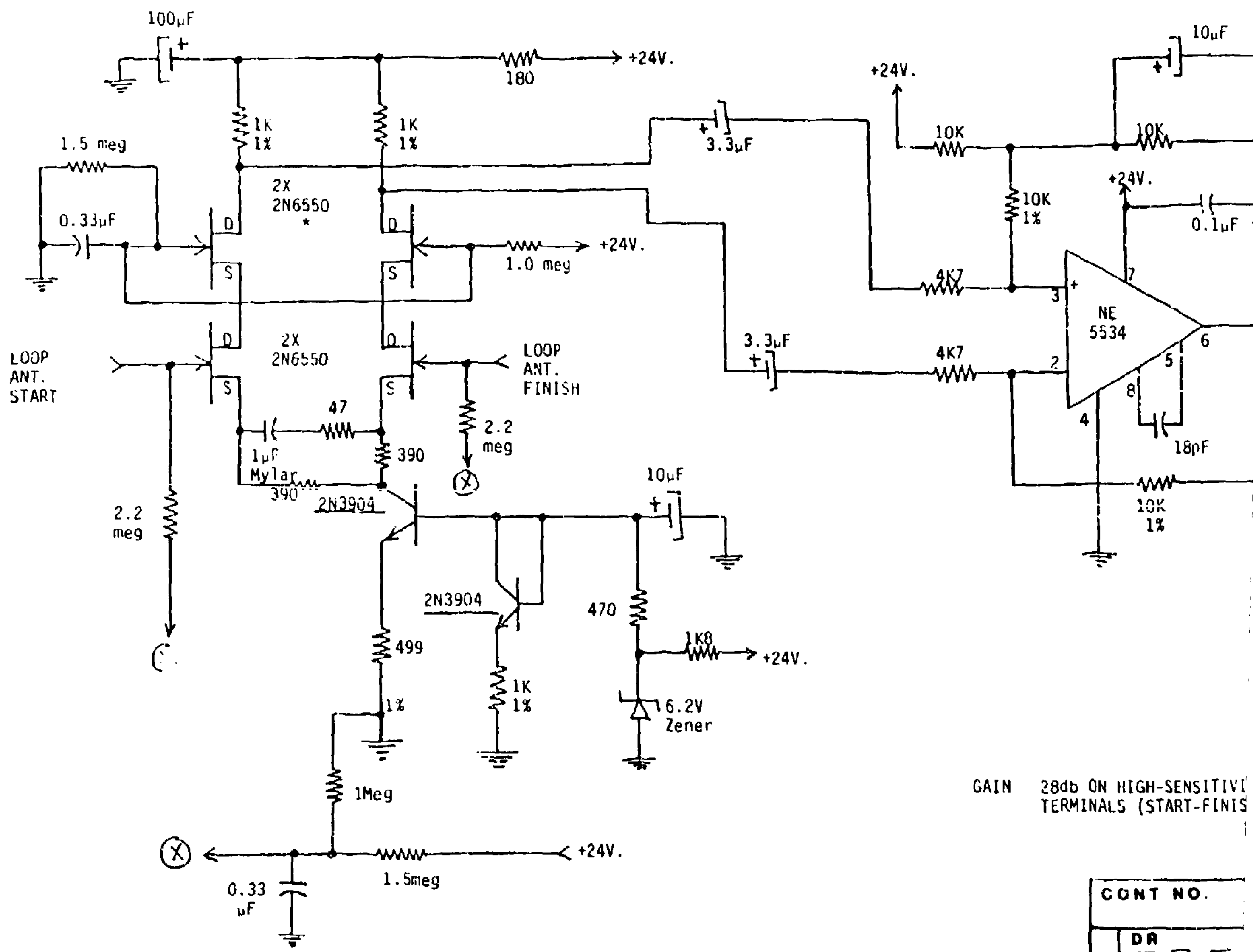
* Adjust for 2.55Volts D.C. at point B when outputs are at 15.1 MHz.

Figure A-12. 15.1 MHz Local oscillator

CONT NO.	
DRFTG	DR D.B.TAL
	APPD
	CHK
ENGRG	DEV
	E/M
	PROJ



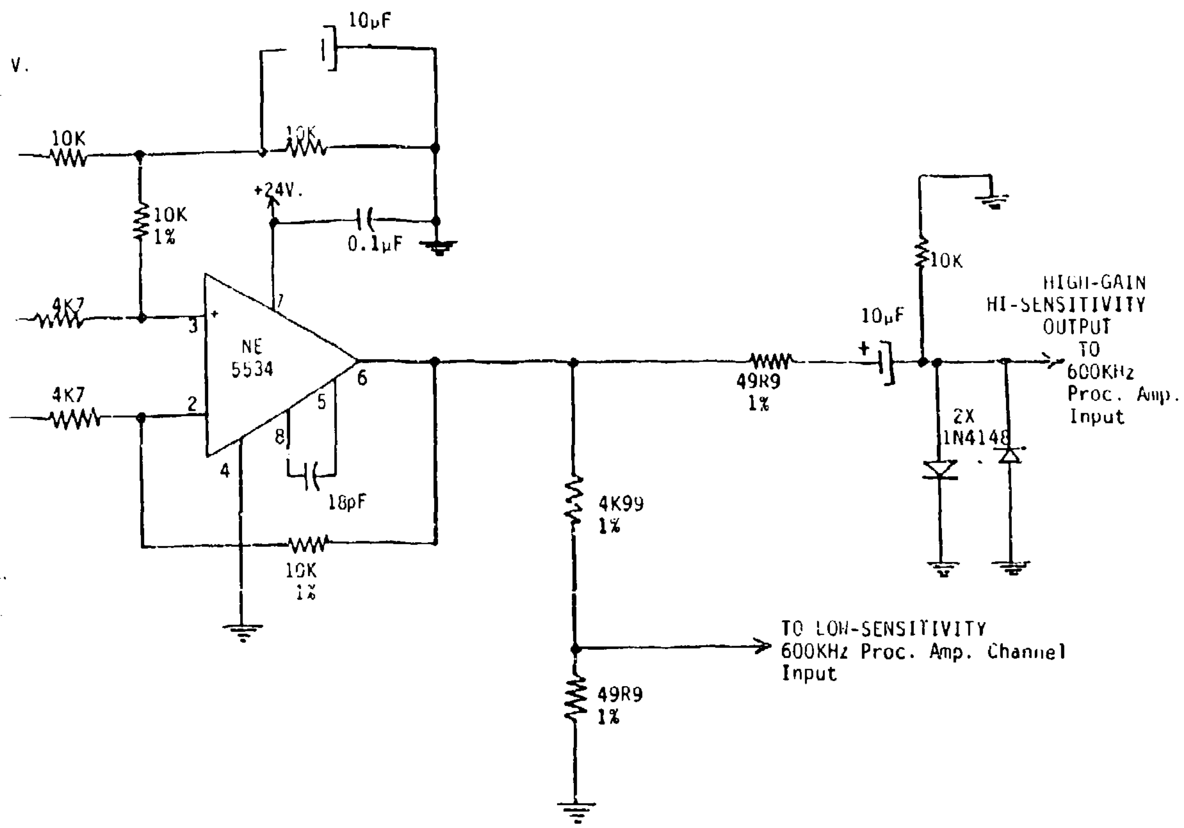
CONT NO.	RADANT SYSTEMS, INC. 266 HUDSON ROAD STOW, MASSACHUSETTS (617) 562-3866		
DR: D.B. TALBOT DATE: JUL 26 83	**LOCAL OSCILLATOR**		
APPD	**15.1 MHz**		
CHK			
DEV			
E/M			
PROJ	SIZE: B	CODE IDENT	DRAWING NO.: -580
	SCALE		SHEET 2 OF 2



* 2N6550 MANUFACTURED BY TELEDYNE/CRYSTALONICS

Figure A-13. 10-600 KHz differential front-end.

CONT NO.	
DRFTG	DR D.B.TA
	APPD
	CHK
ENGRG	DEV
	E/M
	PROJ



GAIN 28db ON HIGH-SENSITIVITY FROM DIFFERENTIAL LOOP ANTENNA TERMINALS (START-FINISH) to PROC. AMP. INPUT

CONT NO.

DRFTG
DR D.B. TALBOT DATE JUL 27,83
APPD
CHK

ENGRG
DEV
E/M
PROJ

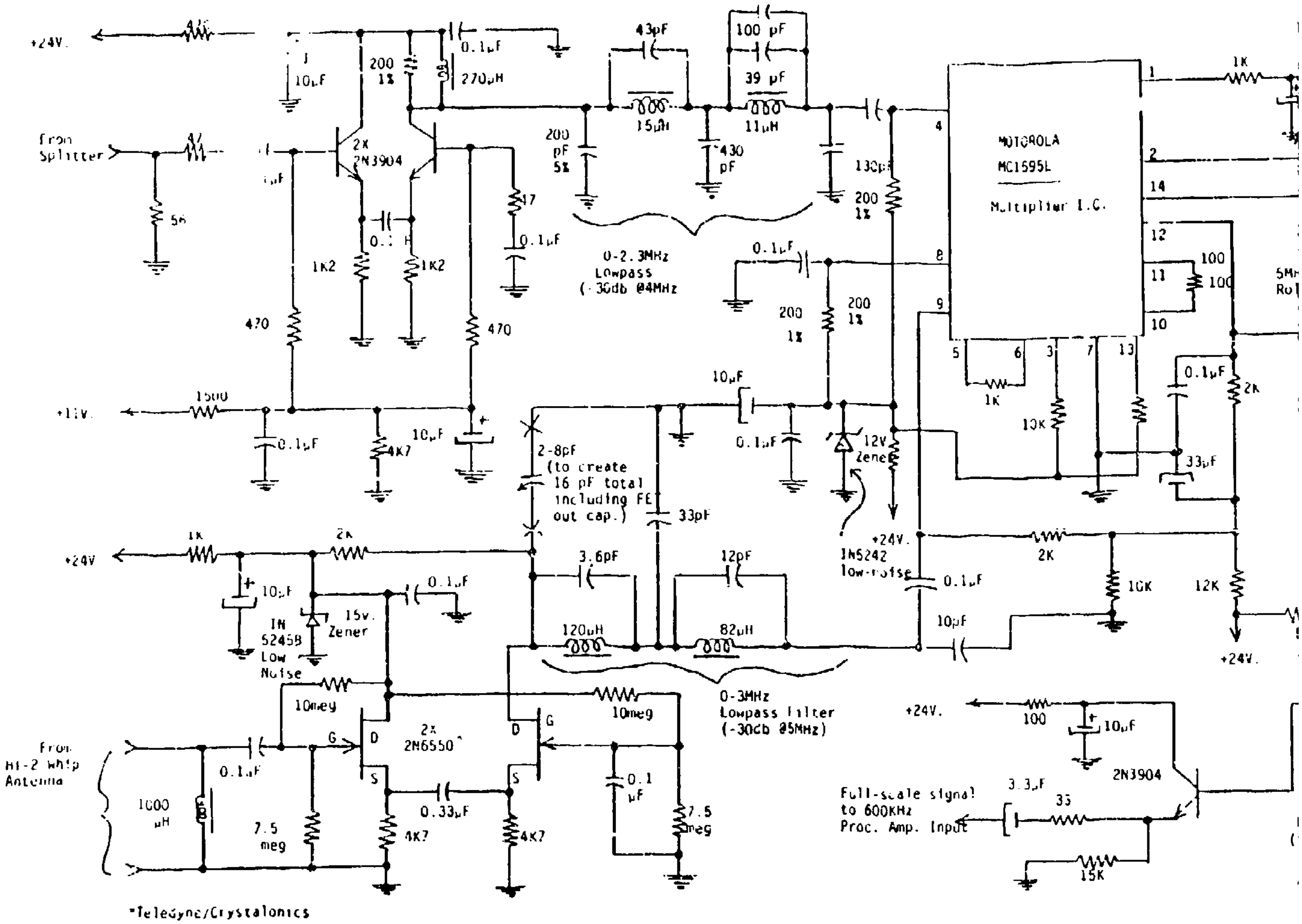
RADANT SYSTEMS, INC.
255 HUDSON ROAD
STOW, MASSACHUSETTS
(617) 562-3866

FRONT END 10-600 KHz (DIFFERENTIAL)

SIZE | CODE IDENT | DRAWING NO. -587

SCALE — | SHEET 1 OF 1

DO NOT SCALE PRINT

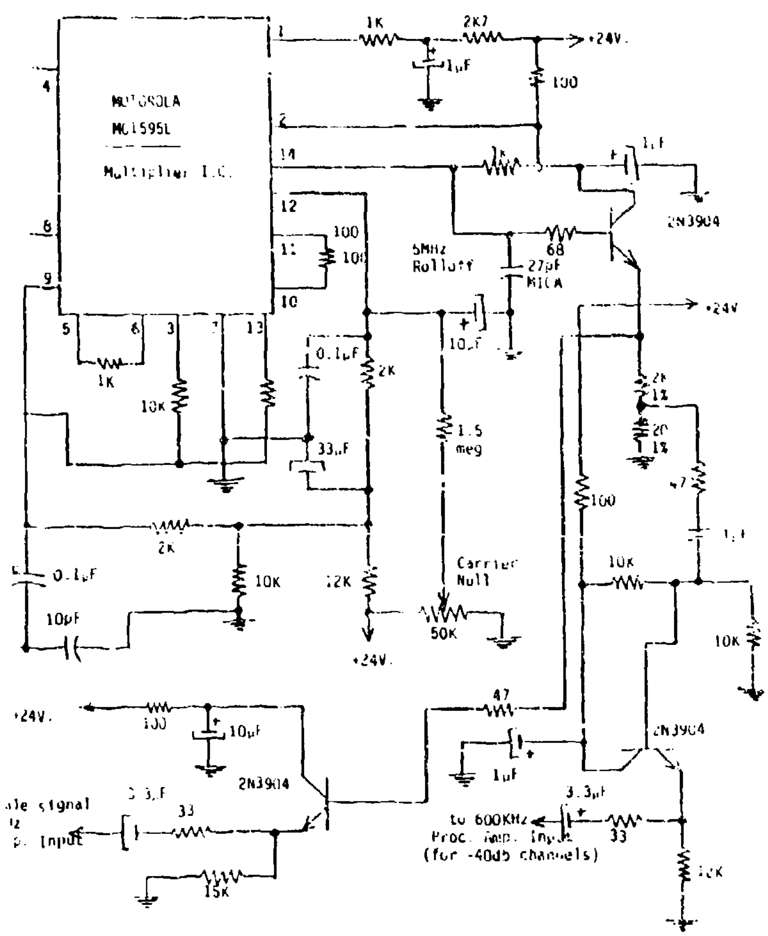


CONT NO.

DRFTG	
DR	D.B.
APPD	
CHK	

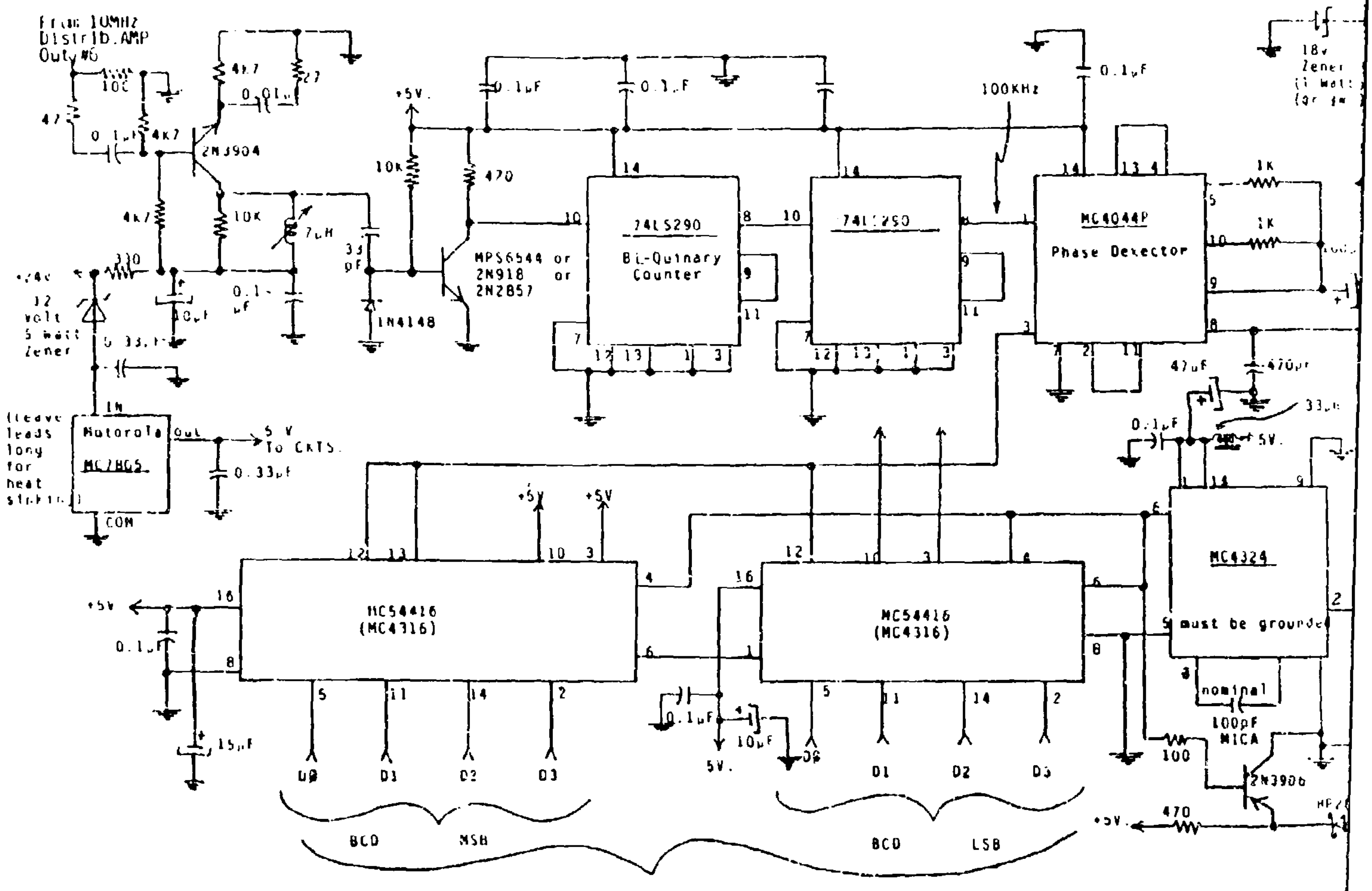
ENGRG	
DEV	
E/M	
PROJ	

Figure A-14. 1.5/2.3 MHz L.O. Buffer/Mixer.



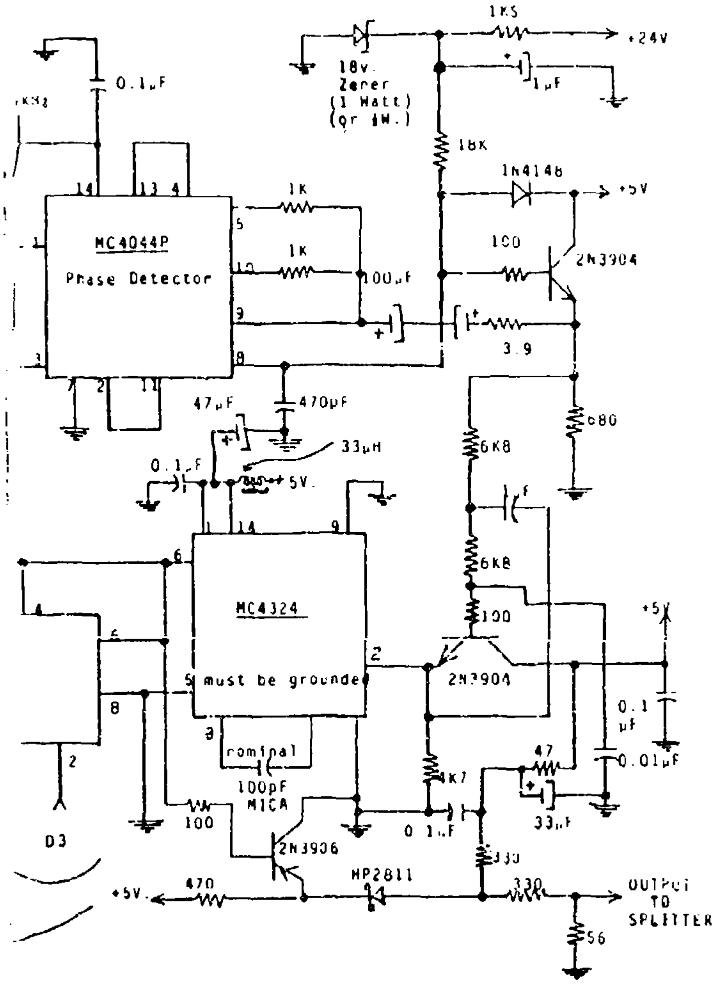
CONT NO.	RADANT SYSTEMS, INC. 255 HUDSON ROAD STOW, MASSACHUSETTS (617) 562-3866
DRFTG DR D.B.TALBOT DATE JUL 24,83	L.O. BUFFER, MIXER & FET FRONT END (2.3 MHz)
APPD	
CHK	
ENGRG DEV	
E/M	SIZE B / CODE IDENT / DRAWING NO. -589
PROJ.	SCALE — / SHEET 1 OF 1

2



CODE (15 = 1.5MHz; 23 = 2.3MHz) USE DIP SWITCHES TO GROUND = COMMON

CONT NO.	
DRFTG	DR D.B.TAL
	APPD
	CHK
ENG	DEV
	E/M



ITCHES TO GROUND = COMMON

v conver-

CONT NO.	RADANT SYSTEMS, INC. 255 HUDSON ROAD STOW, MASSACHUSETTS (617) 562-3866
DRFTG DR D.B.TALBOT DATE JUL 24,83	
APPD	FREQ. CONVERTER 10 MHz to 2.3 MHz
CHK	
ENGRG DEV	
E/M	SIZE B / CODE IDENT / DRAWING NO. -591
PROJ	
	SCALE — / SHEET 1 OF 1

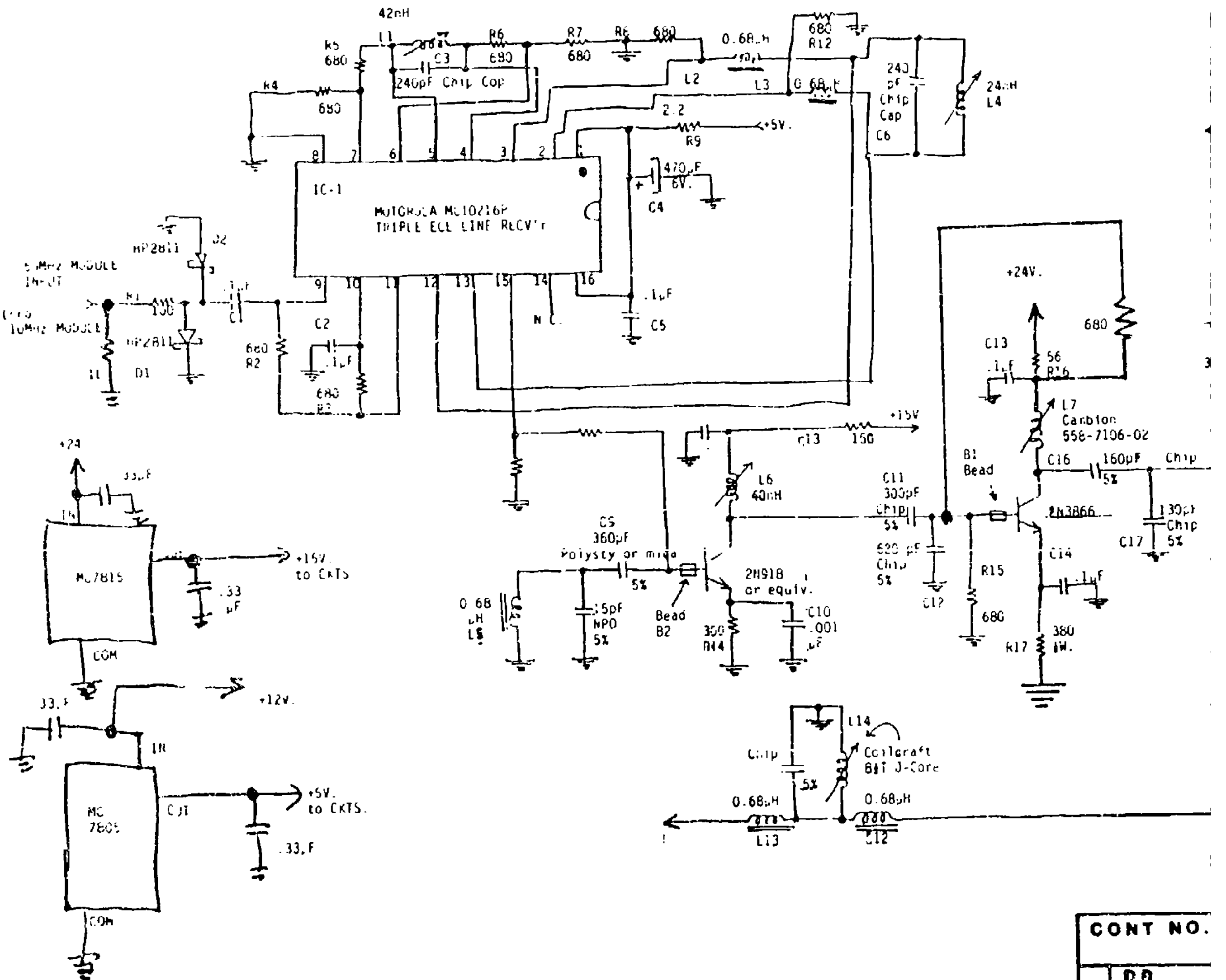


Figure A-16. 50 MHz local oscillator.

CONT NO.

DRFTG

DR D.E

APPD

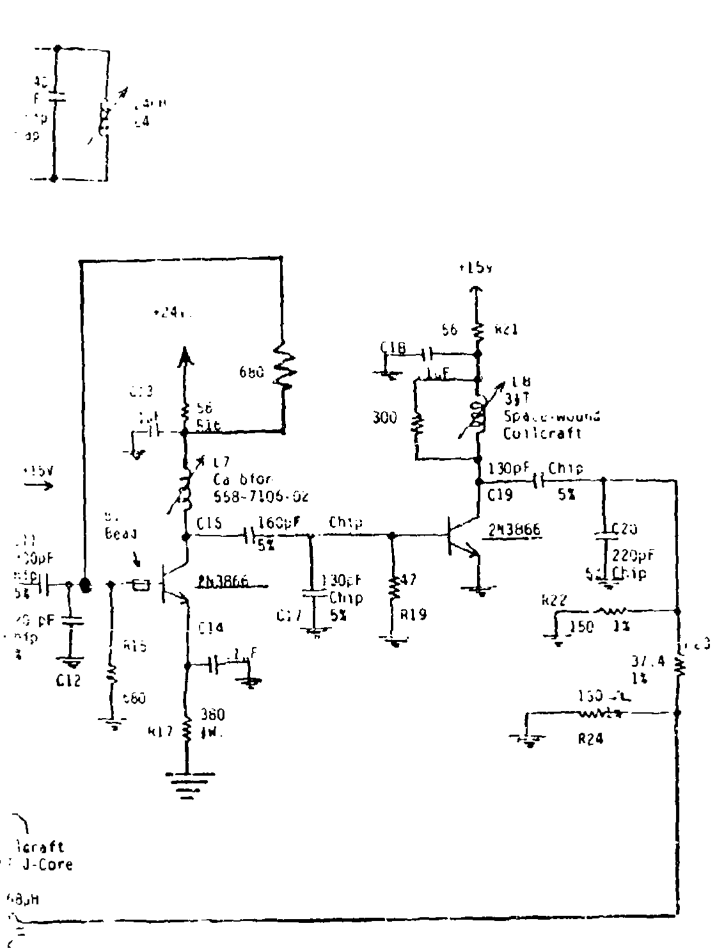
CHK

ENGRG

DEV

E/M

PROJ



z local

CONT NO.	
DRFTG — DR D.B. TALBOT — DATE 5-18-83	RADANT SYSTEMS, INC. 255 HUDSON ROAD STOW, MASSACHUSETTS (617) 562-3866
APPD	LOCAL OSCILLATOR 50 MHz
CHK	
ENGRG — DEV	
E/M	
PROJ	SIZE B — CODE IDENT — DRAWING NO. -579
	SCALE - — SHEET 1 OF 1

DO NOT SCALE PRINT

2

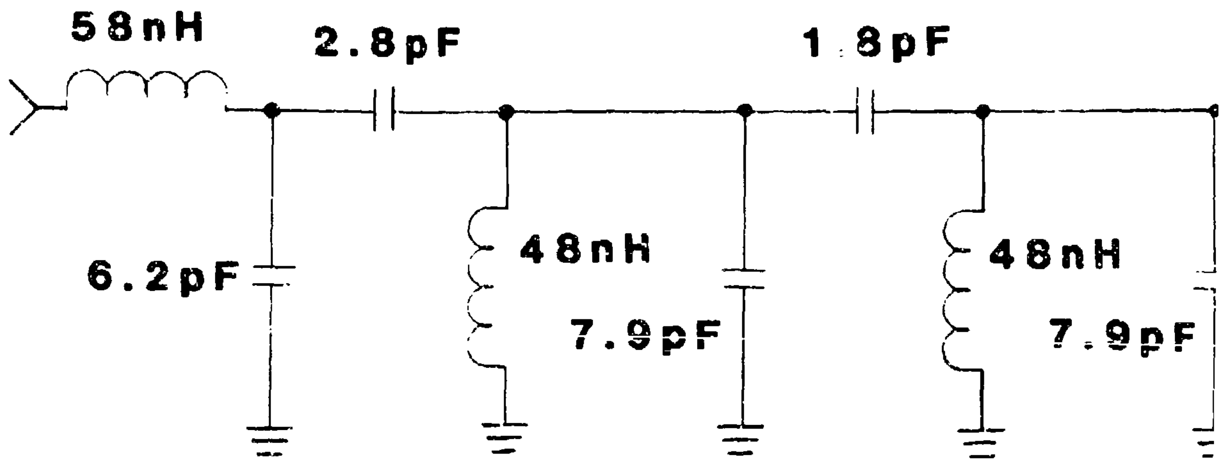


Figure A-17. 220 MHz band pass filter.

G6	G5	G4	G3	G2	G1	ITEM	SIZE

QTY PER ASSY

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES
.XX DECIMAL ± .XXX DECIMAL ±
ANGLES ± SURFACE QUAL √ MAX

MFG

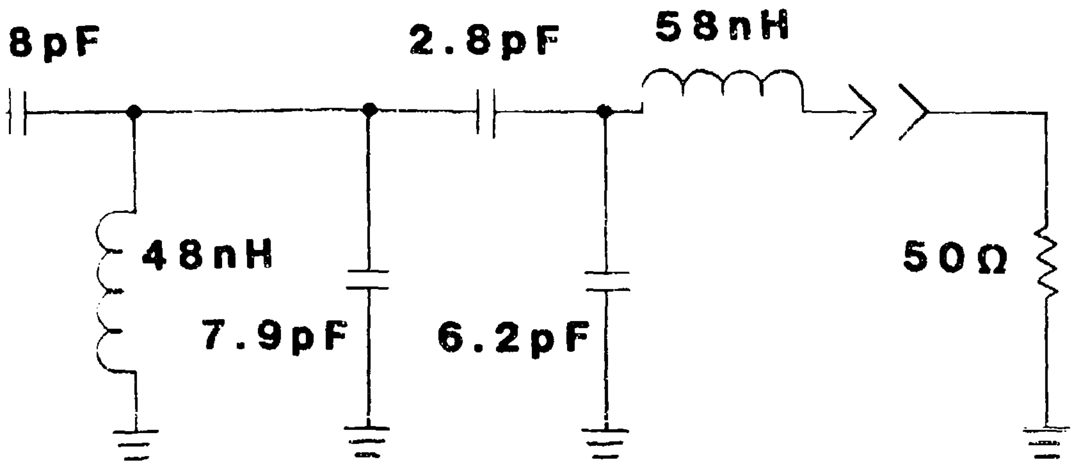
CONT NO.

DRFTG: DR, APPD, CHK

ENGRG: DEV, E/M, PROJ

NEXT ASSY	USED ON
APPLICATION	

REVISIONS				
ZONE	LTR	DESCRIPTION	DATE	APPROVED



MHz band

Note:

1. All Coils assumed to have

$Q_o \geq 120$ at 220 MHz

G3	G2	G1	ITEM	SIZE	PART NUMBER	DESCRIPTION

PARTS LIST

] ASSY	CONT NO.	RADANT SYSTEMS, INC.	255 HUDSON ROAD STOW, MASSACHUSETTS (617) 562-3866
WISE SPECIFIED ARE IN INCHES RANCES .XXX DECIMAL ±	DRFTG DR K.J. Vuskant DATE 15 FEB 84	220 MHz 50Ω Bandpass Filter	
SURFACE QUAL √ MAX	APPD		
	CHK		
	ENGRG DEV		
	E/M	SIZE B	CODE IDENT
	PROJ D. Rogers 15 Feb 84	DRAWING NO. -583	
		SCALE	SHEET OF 1

DO NOT SCALE PRINT

2

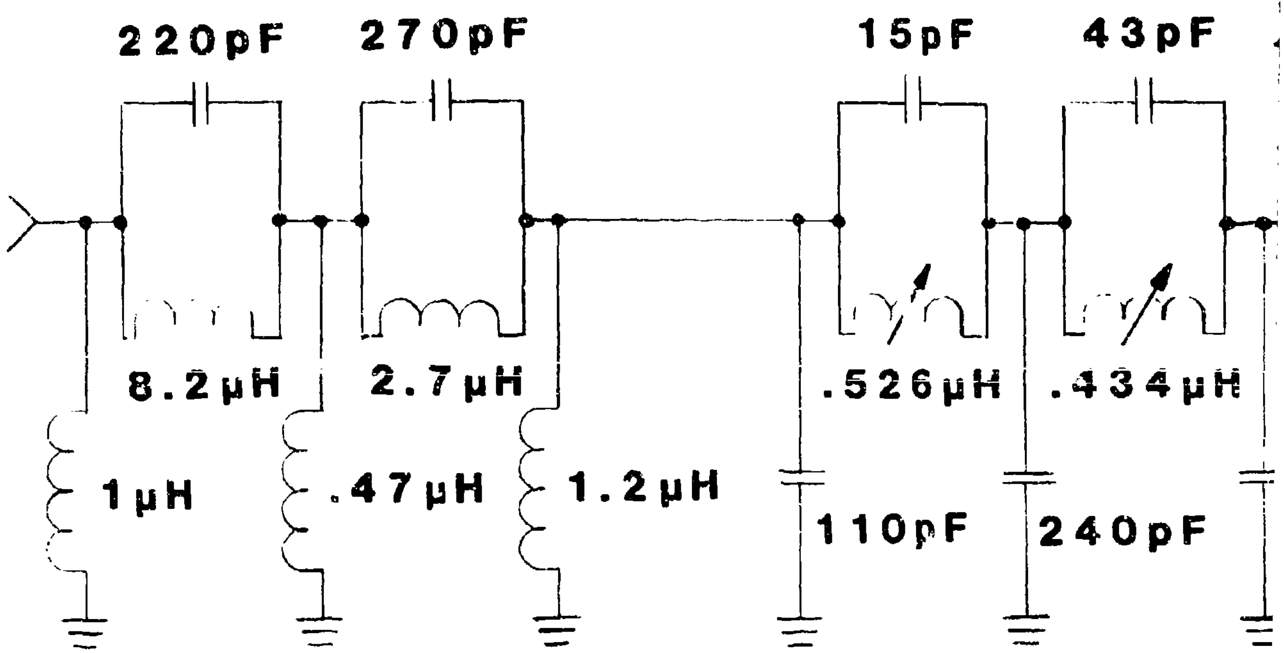


Figure A-18. 15 MHz band pass filter.

G6	G5	G4	G3	G2	G1	ITEM	SIZE

QTY PER ASSY

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES
.XX DECIMAL ± .XXX DECIMAL ±
ANGLES ± SURFACE QUAL √ MAX

CONT NO.

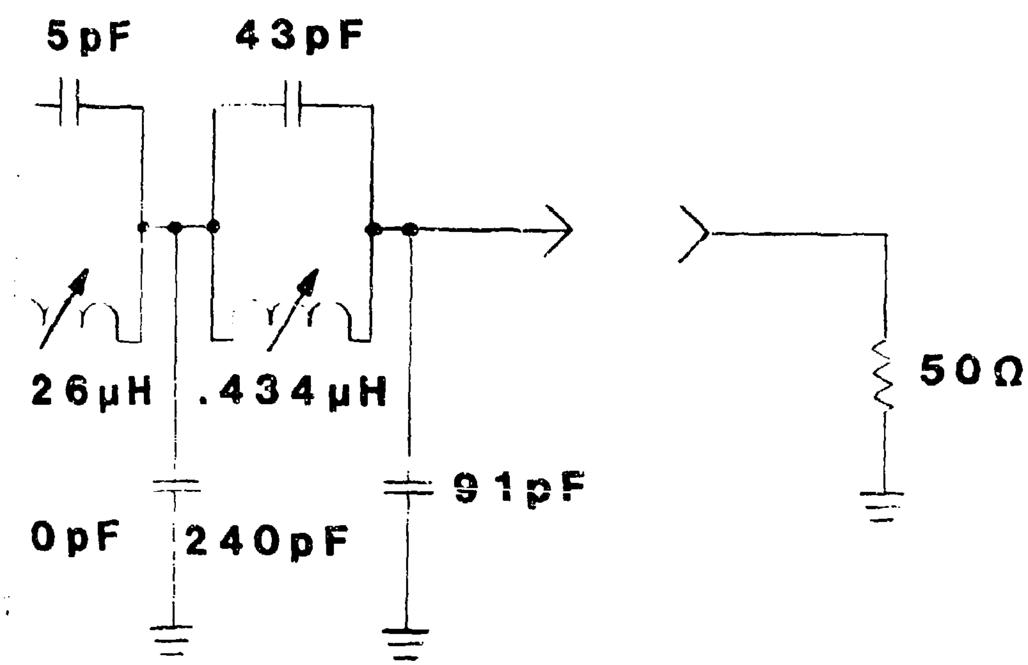
DRFTG: DR, APPD, CHK

ENGRG: DEV, E/M, PROJ

NEXT ASSY	USED ON

MFG

REVISIONS				
ZONE	LTR	DESCRIPTION	DATE	APPROVED



G3	G2	G1	ITEM	SIZE	PART NUMBER	DESCRIPTION

R ASSY

PARTS LIST

..RWISE SPECIFIED
ARE IN INCHES
RANCES
.XXX DECIMAL
±
SURFACE QUAL
√ MAX

CONT NO.

DRFTG — DR: K. Vinkert — DATE: 15 FEB 84
APPD
CHK

ENGRG — DEV
E/M
PROJ: J. Rogers 15 FEB 84

RADANT
SYSTEMS, INC.
255 HUDSON ROAD
STOW, MASSACHUSETTS
(617) 562-3866

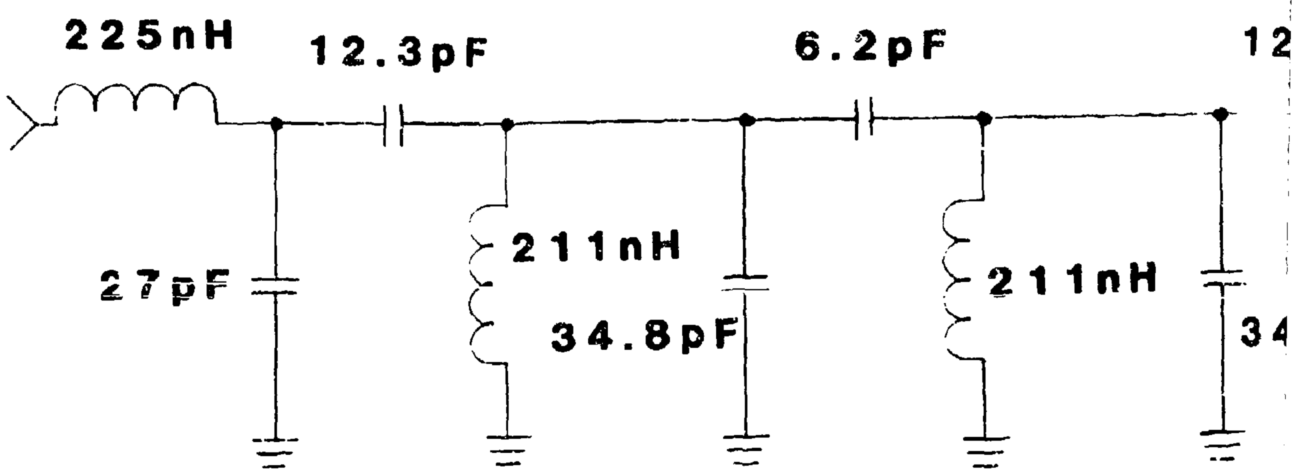
15 MHz Bandpass Filter

SIZE	CODE IDENT	DRAWING NO.
B		-582

SCALE | SHEET OF

DO NOT SCALE PRINT

2



Note:

Figure A-19. 50 MHz band pass filter.

G6	G5	G4	G3	G2	G1	ITEM	SIZE
QTY PER ASSY							

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES
.XX DECIMAL ± .XXX DECIMAL ±
ANGLES ± SURFACE QUAL √ MAX

CONT NO.

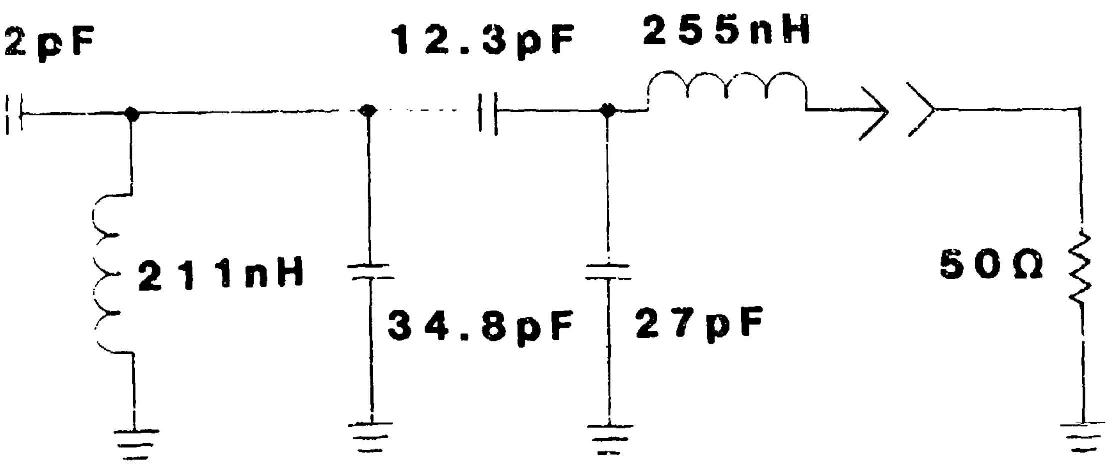
DRFTG: DR, APPD, CHK

ENGRG: DEV, E/M, PROJ

MFG

NEXT ASSY	USED ON

REVISIONS				
ZONE	LTR	DESCRIPTION	DATE	APPROVED



Note:

1. ALL COILS ARE ASSUMED TO HAVE

$Q_o \geq 120$ at 220 MHz

9. 50 MHz band pass

G4	G3	G2	G1	ITEM	SIZE	PART NUMBER	DESCRIPTION
PER ASSY				PARTS LIST			

…HERWISE SPECIFIED
…ONS ARE IN INCHES
…OLERANCES
…AL .XXX DECIMAL
±
SURFACE QUAL
√ MAX

CONT NO.

DRFTG: DR K.J. Vieckart DATE 15 FEB 84
APPD
CHK

ENGRG: DEV
E/M
PROJ D. Rogers 15 Feb 84

RADANT SYSTEMS, INC.
255 HUDSON ROAD
STOW, MASSACHUSETTS
(617) 562-3866

50 MHz 50 OHM BANDPASS FILTER

SIZE B | CODE IDENT | DRAWING NO. -584

SCALE | SHEET 1 OF 1

DO NOT SCALE PRINT

2

ZONE

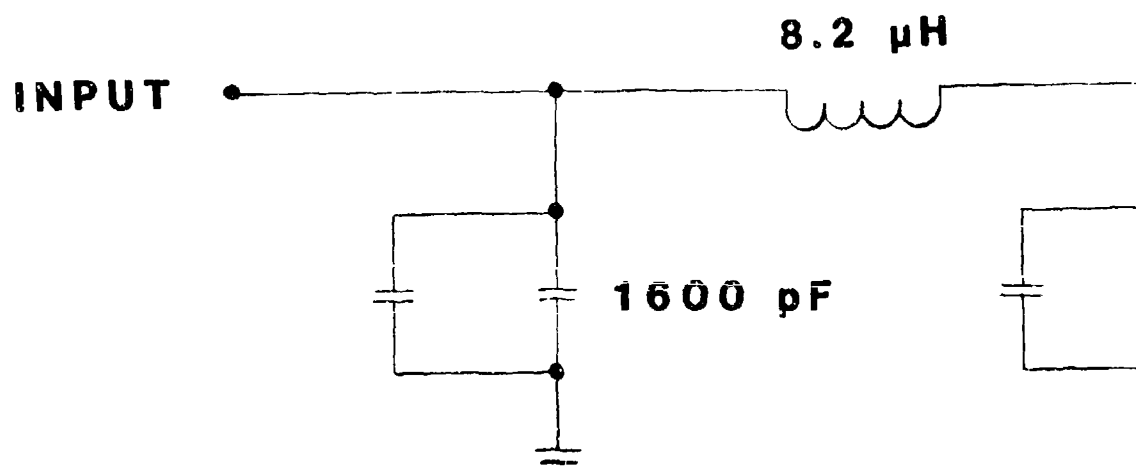


Figure A-20. 2 MHz butterworth low pass filter.

G6	G5	G4	G3	G2	G1	ITEM	SIZE	PA

ɪTY PER ASSY

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES
.XX DECIMAL .XXX DECIMAL
± ±
ANGLES SURFACE QUAL
± √ MAX

CONT NO.

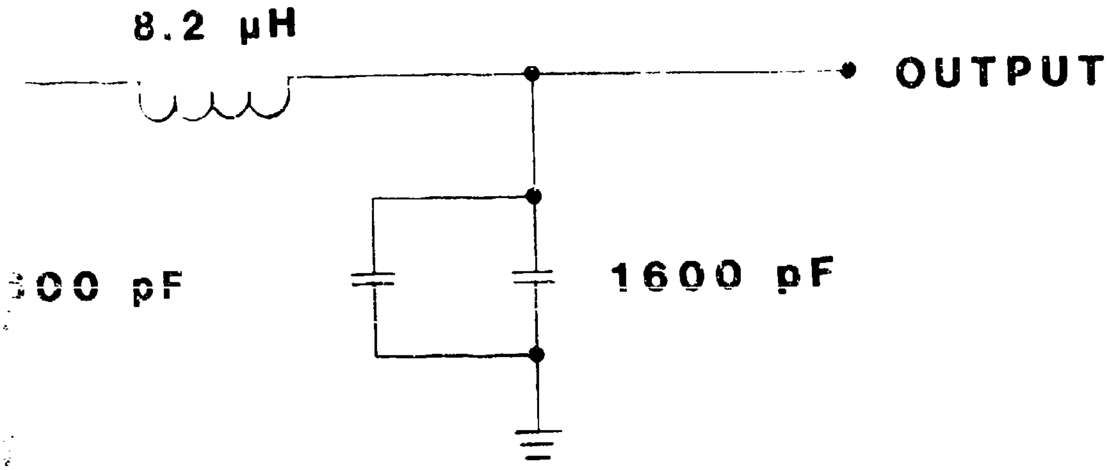
DRFTG
DR RJ Virkent
APPD
CHK

ENGRG
DEV
E/M
PROJ D. Rag

MFG

NEXT ASSY	USED ON
APPLICATION	

REVISIONS				
ZONE	LTR	DESCRIPTION	DATE	APPROVED



1000pF IN PARALLEL WITH 560pF

G4	G3	G2	G1	ITEM	SIZE	PART NUMBER	DESCRIPTION

ER ASSY

PARTS LIST

ERWISE SPECIFIED
NS ARE IN INCHES
LERANCES
AL .XXX DECIMAL
±

SURFACE QUAL
√ MAX

CONT NO.

DRFTG
DR KQ Vickast DATE 5FEB84
APPD
CHK

ENGRG
DEV
E/M
PROJ D. Rogers 15 Feb 84

RADANT SYSTEMS, INC.
255 HUDSON ROAD
STOW, MASSACHUSETTS
(617) 562-3866

2MHz Butterworth

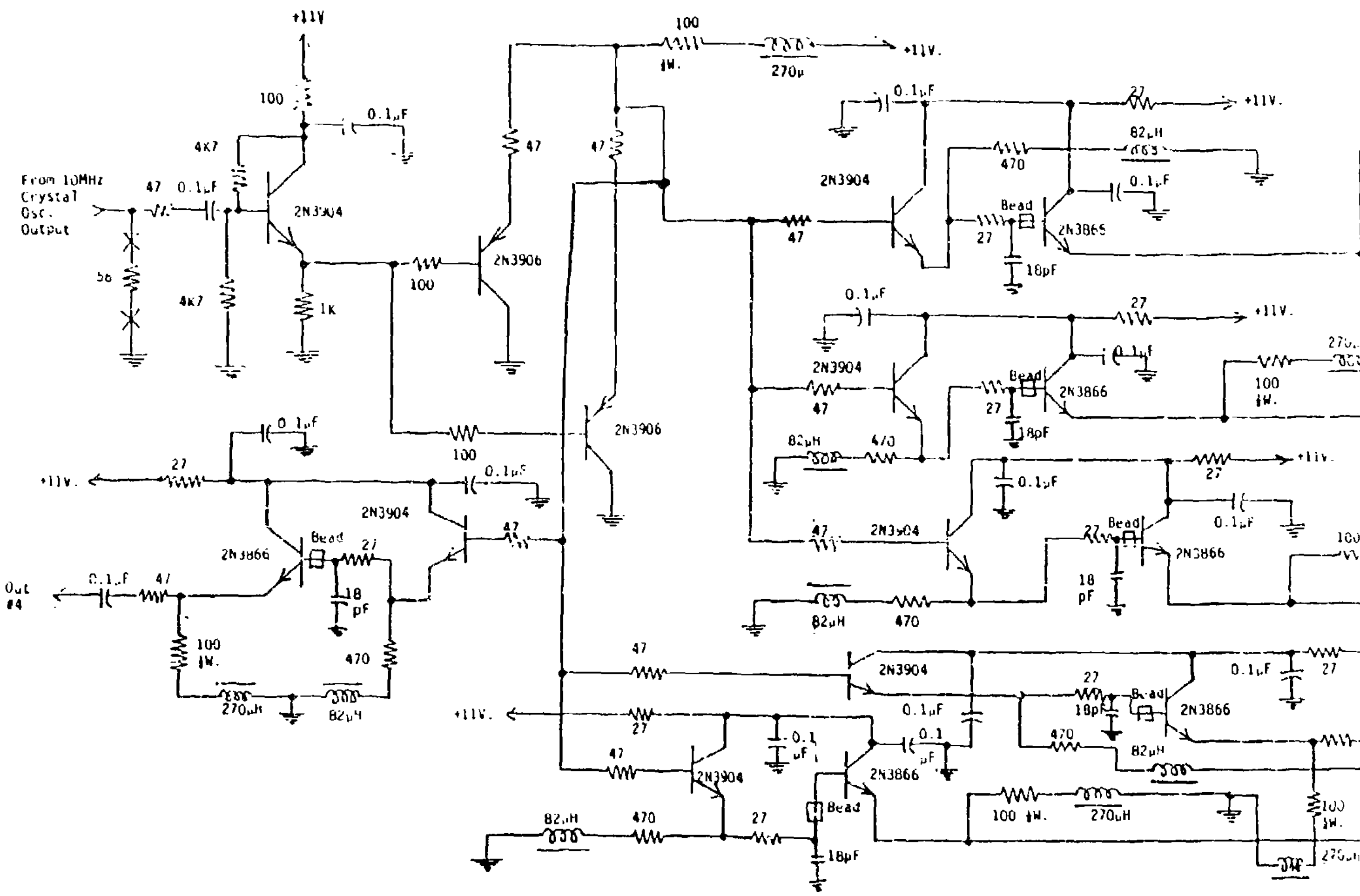
L.P. Filter

SIZE	CODE IDENT	DRAWING NO.
B		-586

SCALE | SHEET 1 OF 1

DO NOT SCALE PRINT

2



CONT NO.

D.B TAL

DRFTG

APPD

CHK

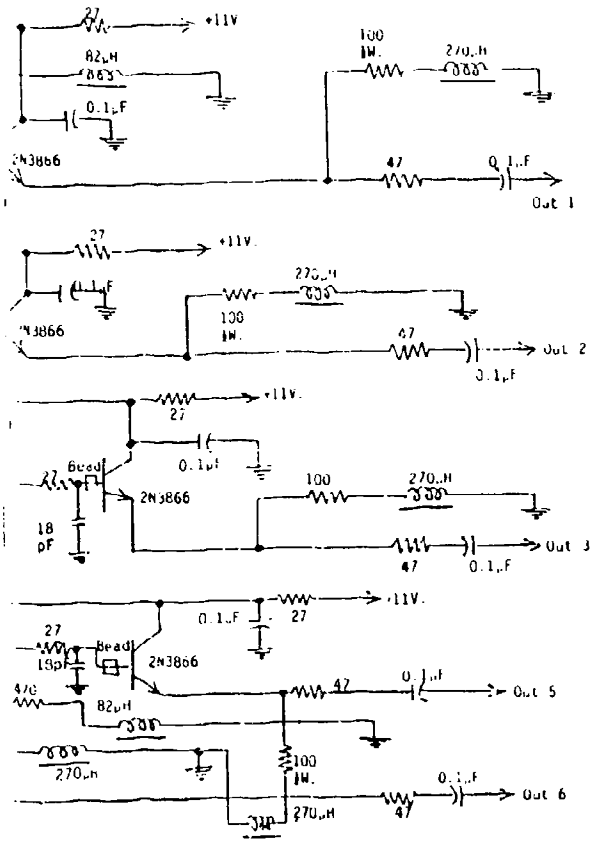
ENGRG

DEV

E/M

PROJ

Figure A-21. 10 MHz distribution amplifier.



CONT NO.

DRFTG

DR D.B. TALBOT DATE JUL 23,83

APPD

CHK

ENGRG

DEV

E/M

PROJ

RADANT SYSTEMS, INC.

255 HUDSON ROAD
STOW, MASSACHUSETTS
(617) 562-3866

DISTRIBUTION AMPLIFIER

10 MHz

SIZE B

CODE IDENT

DRAWING NO. -588

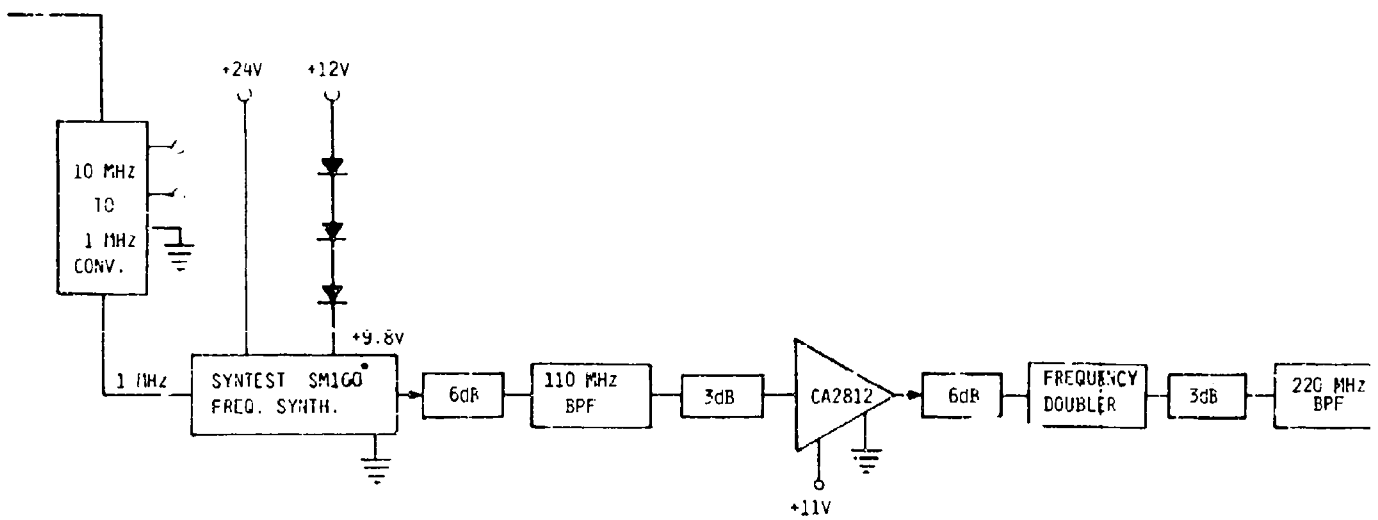
SCALE —

SHEET 1 OF 1

tribu-

DO NOT SCALE PRINT

2



BPF = BANDPASS FILTER

* CODE WIRED for 110MHz Output

Figure A-22. 220 MHz local oscillator.

QTY PER ASSY

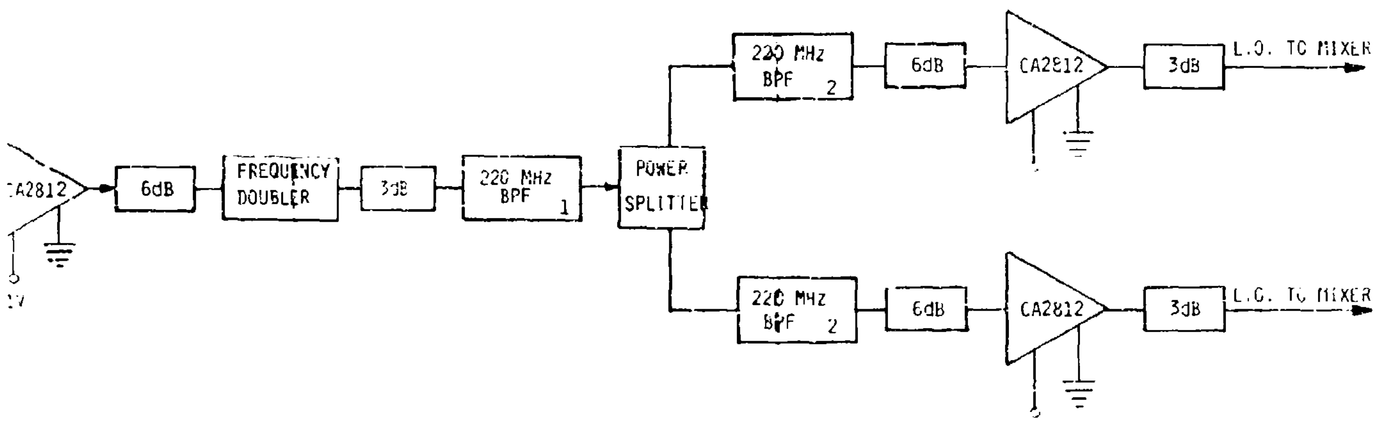
UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES
.XX DECIMAL .XXX DECIMAL
± ±
ANGLES SURFACE QUAL
± √ MAX

NEXT ASSY | USED ON

APPLICATION

MFG

REVISIONS				
ZONE	LTR	DESCRIPTION	DATE	APPROVED



06	05	04	03	02	01	ITEM	SIZE	PART NUMBER	DESCRIPTION
QTY PER ASSY						PARTS LIST			

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES
XX DECIMAL ± XXX DECIMAL ±
ANGLES ± SURFACE QUAL √ MAX

CONT NO
DRFTG: DR, DATE, APPD, CHK
ENGRG: DEV, S/M, PROJ

MFG

NEXT ASSY | USED ON
APPLICATION

RADANT SYSTEMS, INC
[illegible] HUDSON ROAD
STOW, MASSACHUSETTS
(617) [illegible]

LOCAL OSCILLATOR

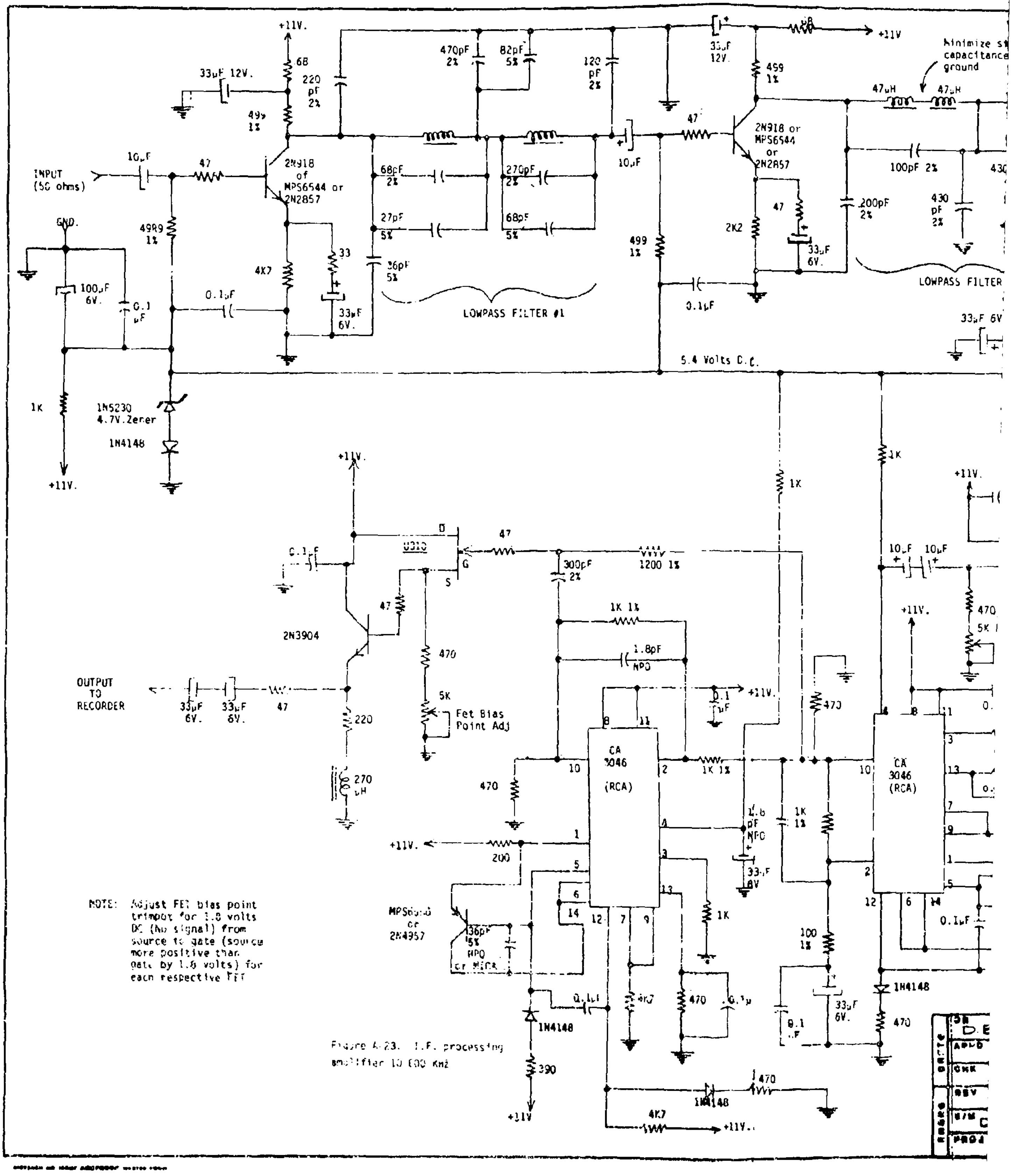
220 MHz

SIZE	CODE IDENT	DRAWING NO
C		-563

SCALE | SHEET 1 OF 1

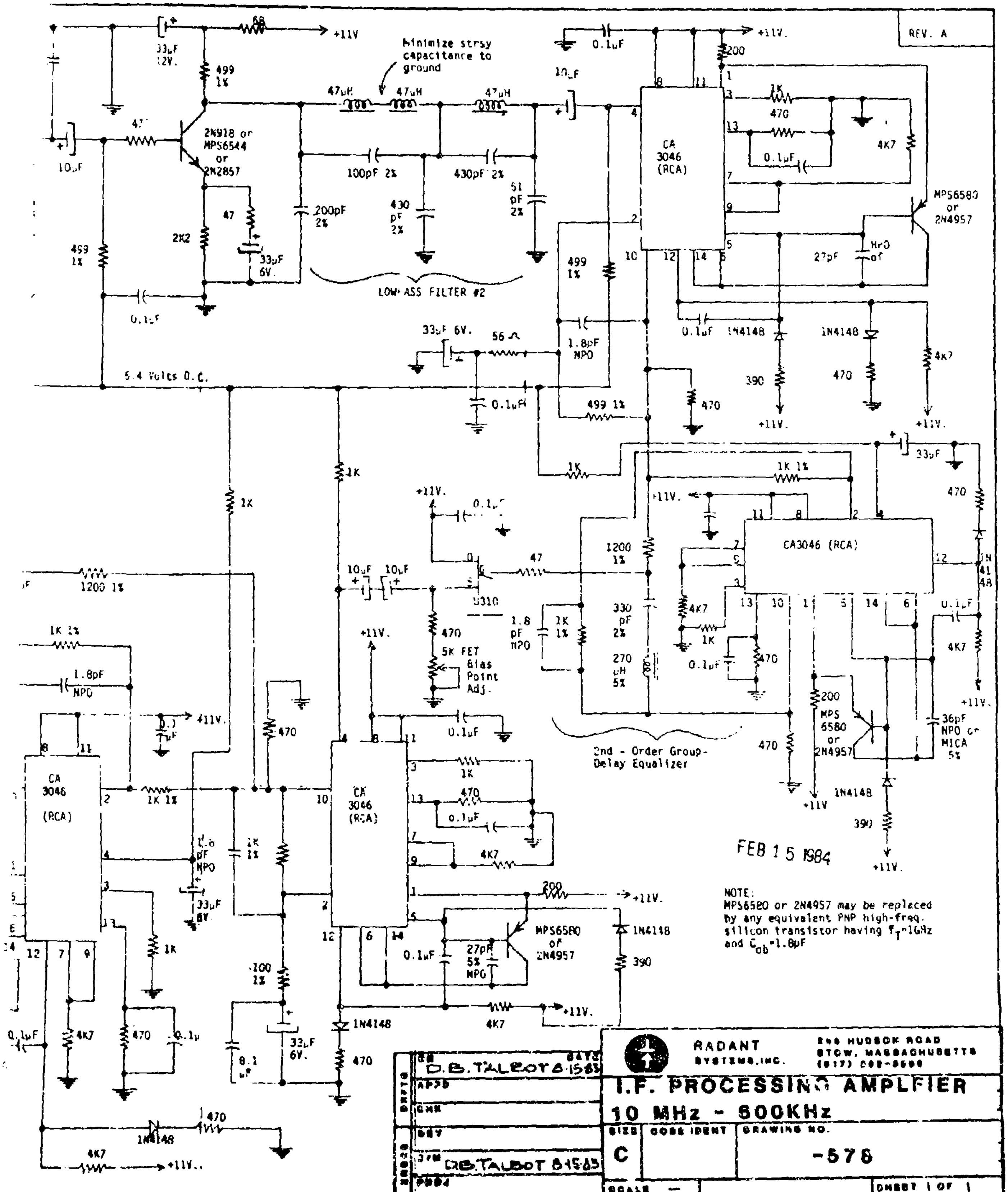
DO NOT SCALE PRINT

2



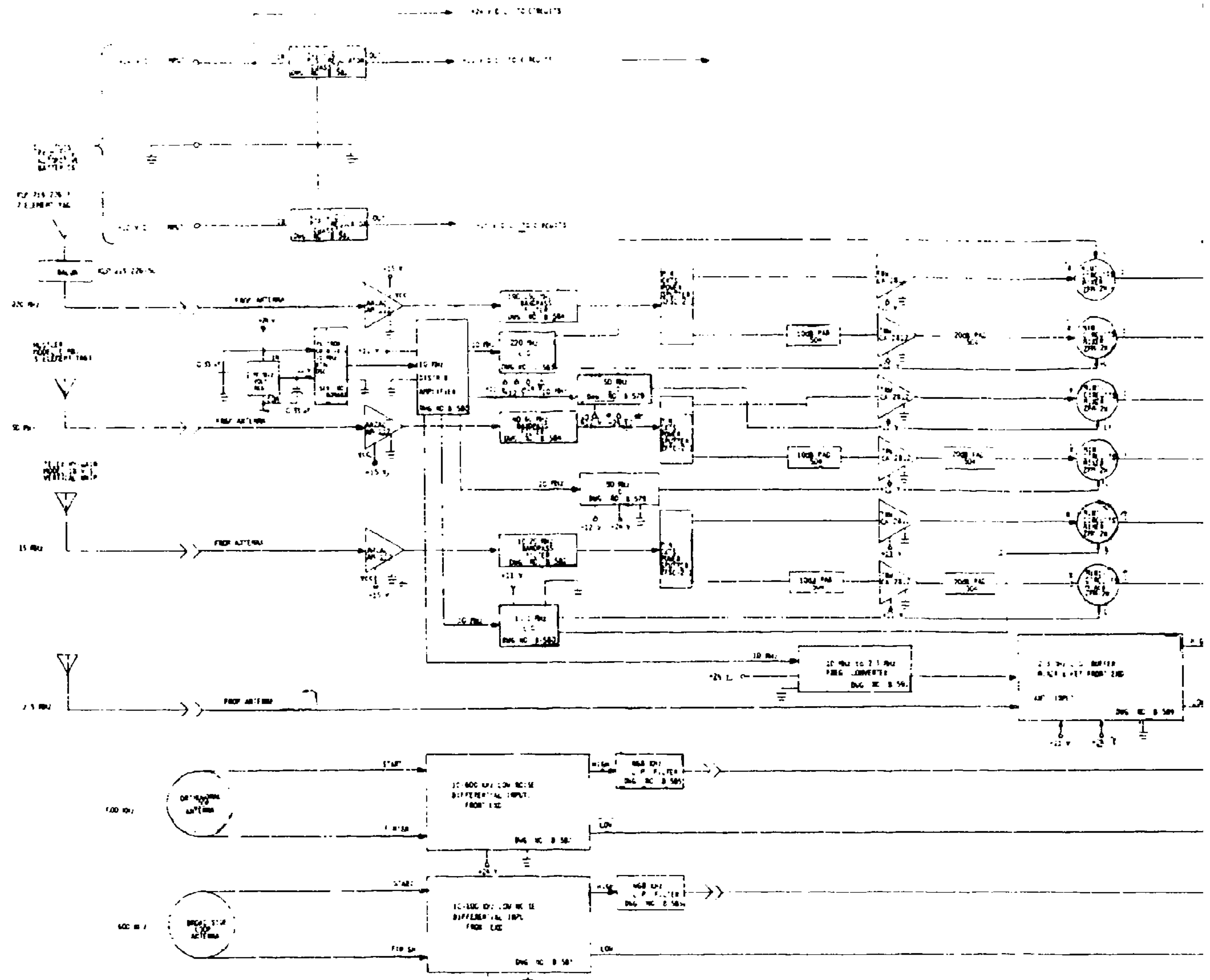
NOTE: Adjust FET bias point trimpot for 1.6 volts DC (no signal) from source to gate (source more positive than gate by 1.6 volts) for each respective FET

Figure A-23. I.F. processing amplifier 10 000 KHz



DO NOT SCALE PRINT

2



PARTS LIST	
DESCRIPTION	DWG NO
220 MHz L.O.	C 583
I.F. PROC. AMP.	C 57?
L.O. 50 MHz	B 576
L.O. 15.2 MHz	B 580 (2 SHEETS)
P.S. REGULATOR 1? V	B 58.
B.P. FILTER 15 MHz	B 582
B.P. FILTER 220 MHz	B 583
B.P. FILTER 50 MHz	B 584
L.P. FILTER 450 kHz	B 585
L.P. FILTER 2 MHz	B 586
FRONT END 10-600 kHz	B 587
DIST. AMPL. 10 MHz	B 588
L.O. BUFFER	B 589
FREQ. CONV.	B 59.
VOLT REG. ?5 V D.C.	B 59.

Figure A-24. Multi-Channel frequency converter block diagram.

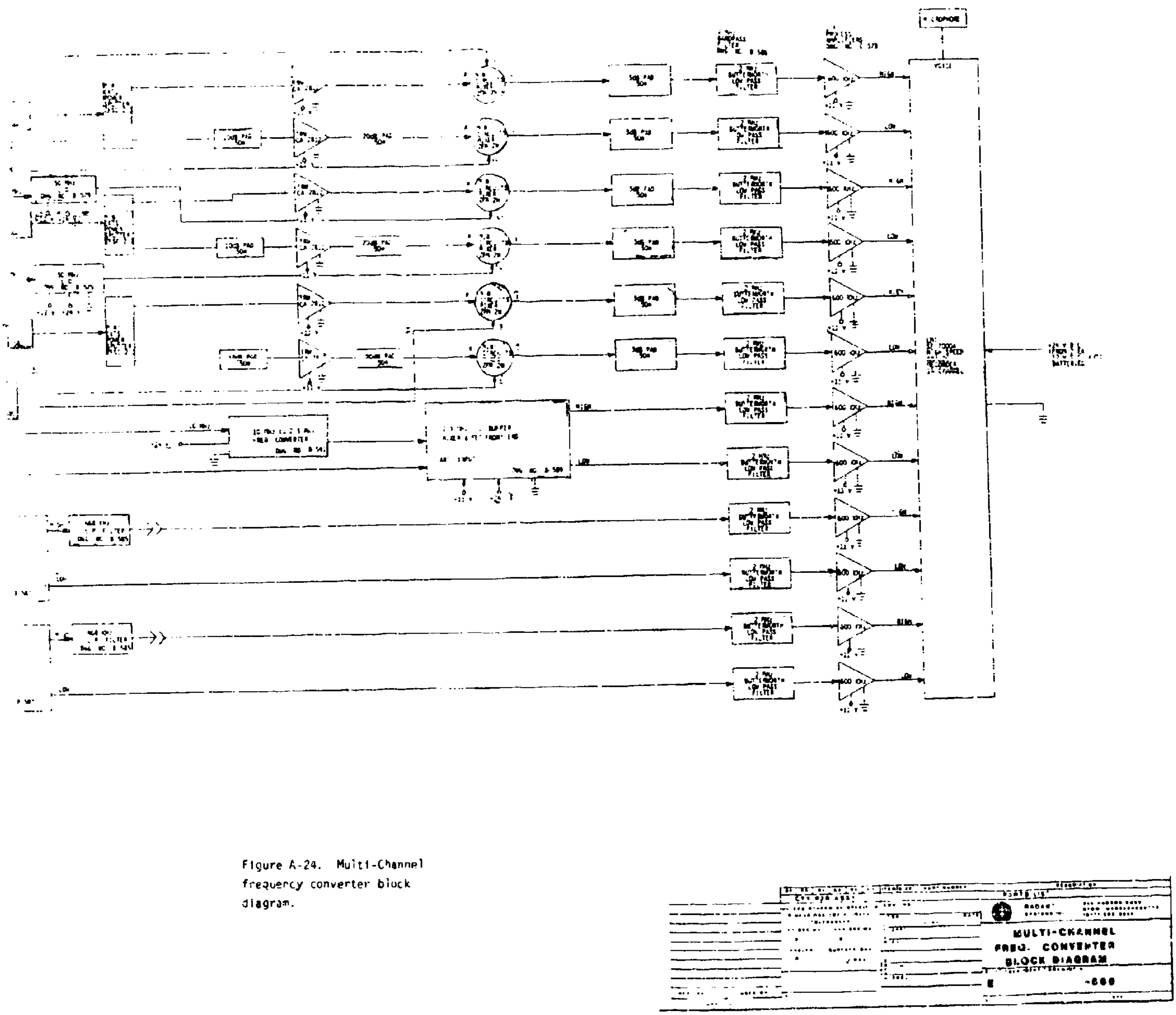


Figure A-24. Multi-Channel frequency converter block diagram.

APPENDIX - B

RENTAL HARDWARE SPECIFICATIONS

Specifications for the rental equipment are presented in Figures B-1 through B-5.

Figure B-1. EMI-7000 instrumentation recorder

TRANSPORT SPECIFICATION

TAPE TRANSPORT

Controls (local):
FAST FORWARD, FAST REVERSE, RUN FORWARD, RUN REVERSE, RECORD, STOP, POWER, READY, eight tape speeds by rotary switch, TAPE/TACH [illegible] switch for AUTO-[illegible] [illegible] COMPENSATION, LOCAL/REMOTE. Push button illumination indicates command accepted.

Controls (remote):
All local controls except POWER and LOCAL/REMOTE, selected by TTL levels. Each tape speed change inhibited in REMOTE condition.

Remote status indication:
A separate multiway output socket is provided giving TTL status indication of following conditions: READY, FAST FORWARD, FAST REVERSE, SYNC. FWD., SYNC. RVS., STOP, RECORD.

Transport features:
Optical low tape sensors
Tape elapsed meter
Fail safe in event of supply failure

Reels:
Precision - up to 26.67 cm ($10\frac{1}{2}$ in) maximum, 7.6 cm (3 in) hubs

Tape width:
2.54 cm (1 in) or 1.27 cm ($\frac{1}{2}$ in). Performance established using 2.54 cm (1 in) tape

Tape:
25.4 µm (0.001 in). Also suitable for use with 12.7 µm (0.0005 in) base. Performance established with SE Labs recommended 25.4 µm (0.001 in) base instrumentation tape unless stated otherwise.

Tape speed accuracy:
±0.5% at all speeds (tachometer mode).

Flutter:
Measured per IRIG [illegible] (IRIG standard 106-75)

Tape Speed cm/s	(ips)	Flutter Bandwidth	Flutter % P-P Tach Servo
304	(120)	0.2 Hz to 10 kHz	0.20
152	(60)	0.2 Hz to 10 kHz	0.20
76	(30)	0.2 Hz to 5 kHz	0.20
38	(15)	0.2 Hz to 2.5 kHz	0.30
19	($7\frac{1}{2}$)	0.2 Hz to 1.25 kHz	0.35
9.5	($3\frac{3}{4}$)	0.2 Hz to 625 Hz	0.45
4.75	($1\frac{7}{8}$)	0.2 Hz to 312 Hz	0.55
2.37	($\frac{15}{16}$)	0.2 Hz to 312 Hz	0.85

Start time:
Less than 6 sec to speed at 304 cm/s (120 ips)

Stop Time:
Less than 6 sec from 304 cm/s (120 ips)

Reversal time:
12 sec. to change from 120 ips FWD to 120 ips RVS

Fast mode:
Less than 6 mins for 1400 m (4600 ft) under constant tension capstan control

Dynamic skew (I.T.D.E.):
The relative period of time displacement of an event recorded simultaneously on two tracks within a 2.54 cm (1 in) headstack as observed on playback over a 10 sec period is as follows:

Tape speed cm/s	(ips)	I.T.D.E. µs (zero-peak) ADJACENT TRACKS 7 track	14 track	OUTSIDE TRACKS 0.001 base tape
304	(120)	0.16	0.16	1
152	(60)	0.33	0.33	2
76	(30)	0.66	0.66	4
38	(15)	1.32	1.32	8
19	($7\frac{1}{2}$)	2.64	2.64	16
9.5	($3\frac{3}{4}$)	5.28	5.28	32
4.75	($1\frac{7}{8}$)	10.56	10.56	64
2.37	($\frac{15}{16}$)	21.12	21.12	128

Time base error (TBE):
Applicable to Tape Servo mode only
Measured per IRIG 106-75
(IRIG Std 106-75)

Tape Speed cm/s (ips)	Time Base Error Zero-to-peak µ(s)
304 (120)	0.2
152 (60)	0.3
76 (30)	0.55
38 (15)	1.0
19 ($7\frac{1}{2}$)	2.0
9.5 ($3\frac{3}{4}$)	4.0
4.75 ($1\frac{7}{8}$)	6.0
2.37 ($\frac{15}{16}$)	12.0

The reference frequency is 200 kHz at 304 cm/s (120 ips) and pro-rata for other speeds. TAPE or TACH modes are selected by illuminated push buttons. TACH mode is automatically selected during loss of TAPE signal. The capstan can also be phase locked to an external oscillator for non-standard tape speed operation.

Capstan servo:
During the recording process the rotational speed of the capstan is controlled by phase comparison of a pulse train derived from an integral optical tachometer with pulses from an internal reference frequency generator. The resulting error signals are used to modify the instantaneous speed of the capstan.
If the reference frequency is recorded on to one tape track during the recording process the recorded signal can be used on playback in place of the tachometer output. This is possible to reconstitute the timebase of the original data record to very fine limits.

Tape servo bandwidth:
In excess of 250Hz

Power Supply

A choice of built in interchangeable power units is available with SE7000M systems

AC unit:
95V to 130V ac 45 Hz to 400 Hz
190V to 250V ac 45 Hz to 62 Hz
Equipment specification is unaffected by voltage, frequency variations within the ranges specified. Consumption —400 VA.

DC unit:
20V to 39V d.c. without adjustment. (7ch record/reproduce or 14ch record plus monitor or 14ch reproduce)

Environment

Temperature and humidity:
The system, excluding tape limitations, can be operated and stored in categories A1, A2, B1, B2 and B3 of Def STD 0011 TABLE A Extreme values as follows: —

	Operating	Storage
Humidity	5% to 95% (Non-Condensing)	5% to 95% (Non-Condensing)
Temperature 7000M	0°C to + 40°C	-20°C to + 71°C

Vibration:
Including automobile, railway, shipboard, caravan, hovercraft and passenger aircraft. Additional information regarding specific applications available upon request.

Altitude:
3000 m (10,000 ft) operating
15,000 m (50,000 ft) storage

Physical

SE7000M

Size:
65 cm × 44 cm × 38 cm
(25.6 in × 17.3 in × 15 in)

Weight:
45 kg (99 lb) for complete 14 channel system excluding tape and spool

Headstacks

All headstacks, where applicable comply with IRIG 106-75 and are warranted for 1000 hours against failure with recommended tape.

Options

Tape width conversion kit:
Kits are available to permit field conversion of tape width 1.27 cm ($\frac{1}{2}$ inch) to 2.54 cm (1 in) (Code TWO) or 2.54 cm (1 in) to 1.27 cm ($\frac{1}{2}$ in) (Code TWH). Conversion takes approximately 30 minutes.

Protective cover (CP):
A quilted PVC cover to provide protection for the recorder during transit on field trials etc.

Servo track reproduce module (TM)
Plugs into relevant reproduce module position in place of data module. Amplifies and equalises control track signal before it is routed to capstan servo circuits. Setting up is facilitated by use of integral LED.

Figure B-2. EMI-7000A specifications sheet

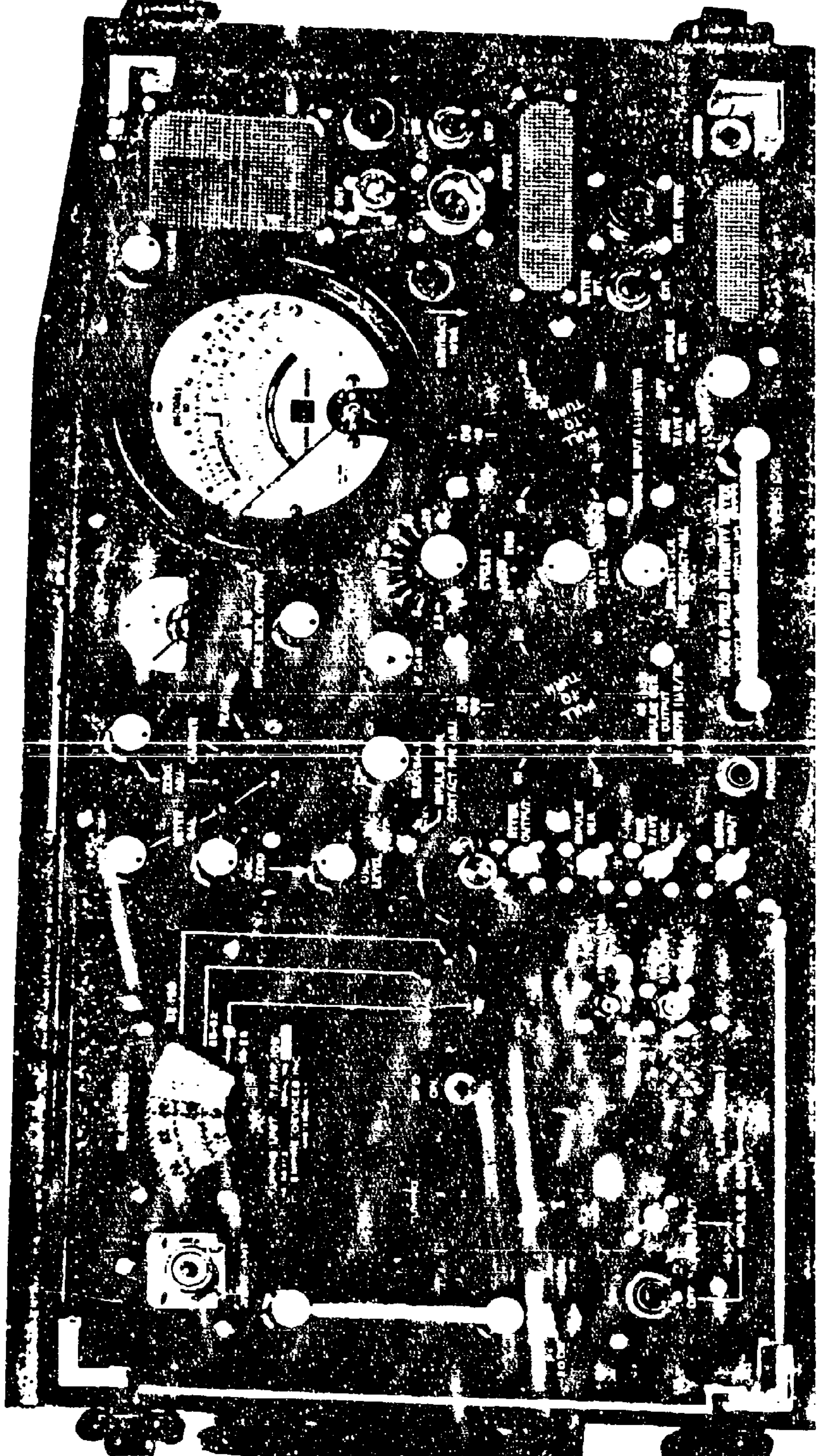


Figure B-3. EMPIRE/NF-105 noise and field intensity meter.

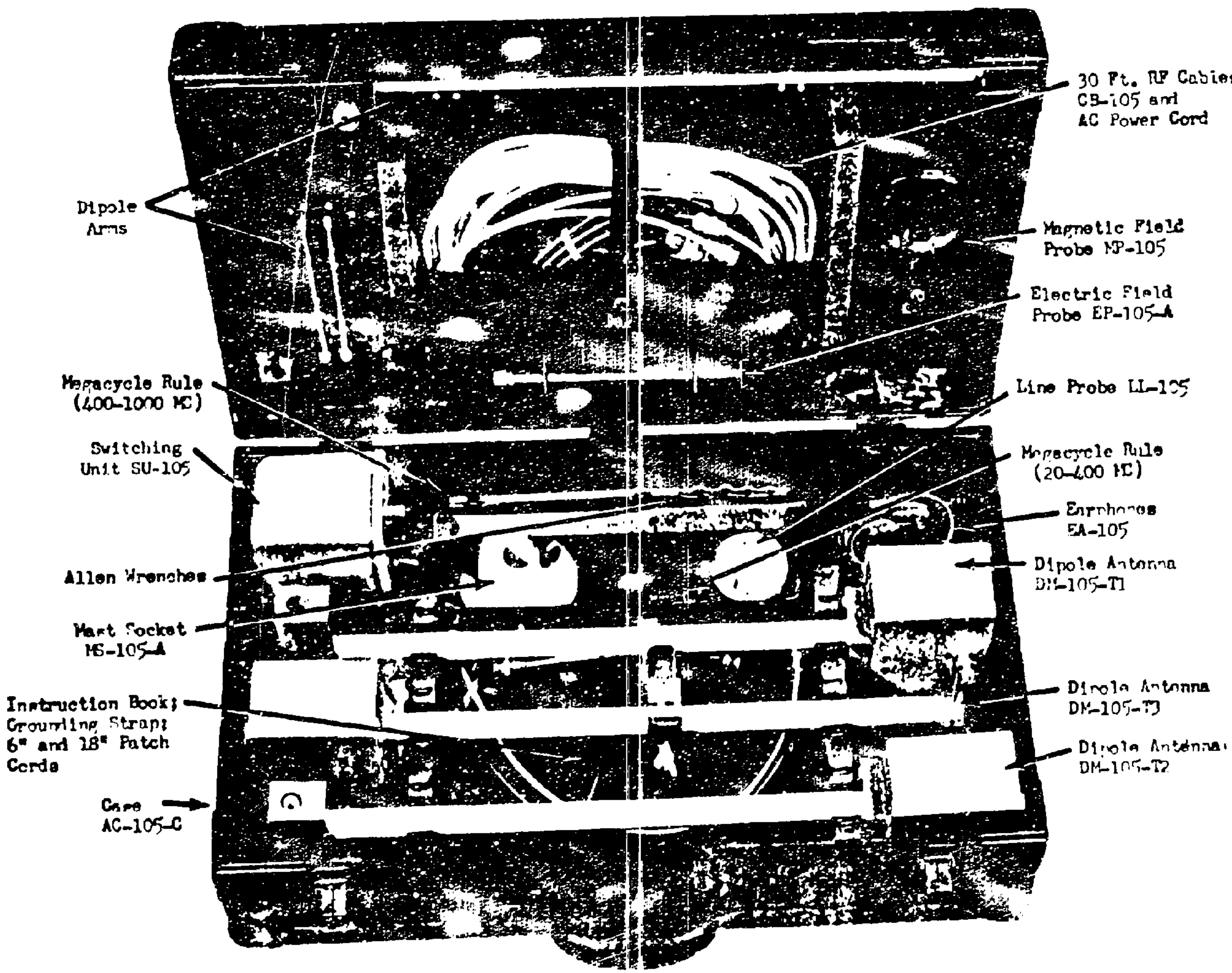


Figure B-4. EMPIRE/NF-105 accessory antenna case.

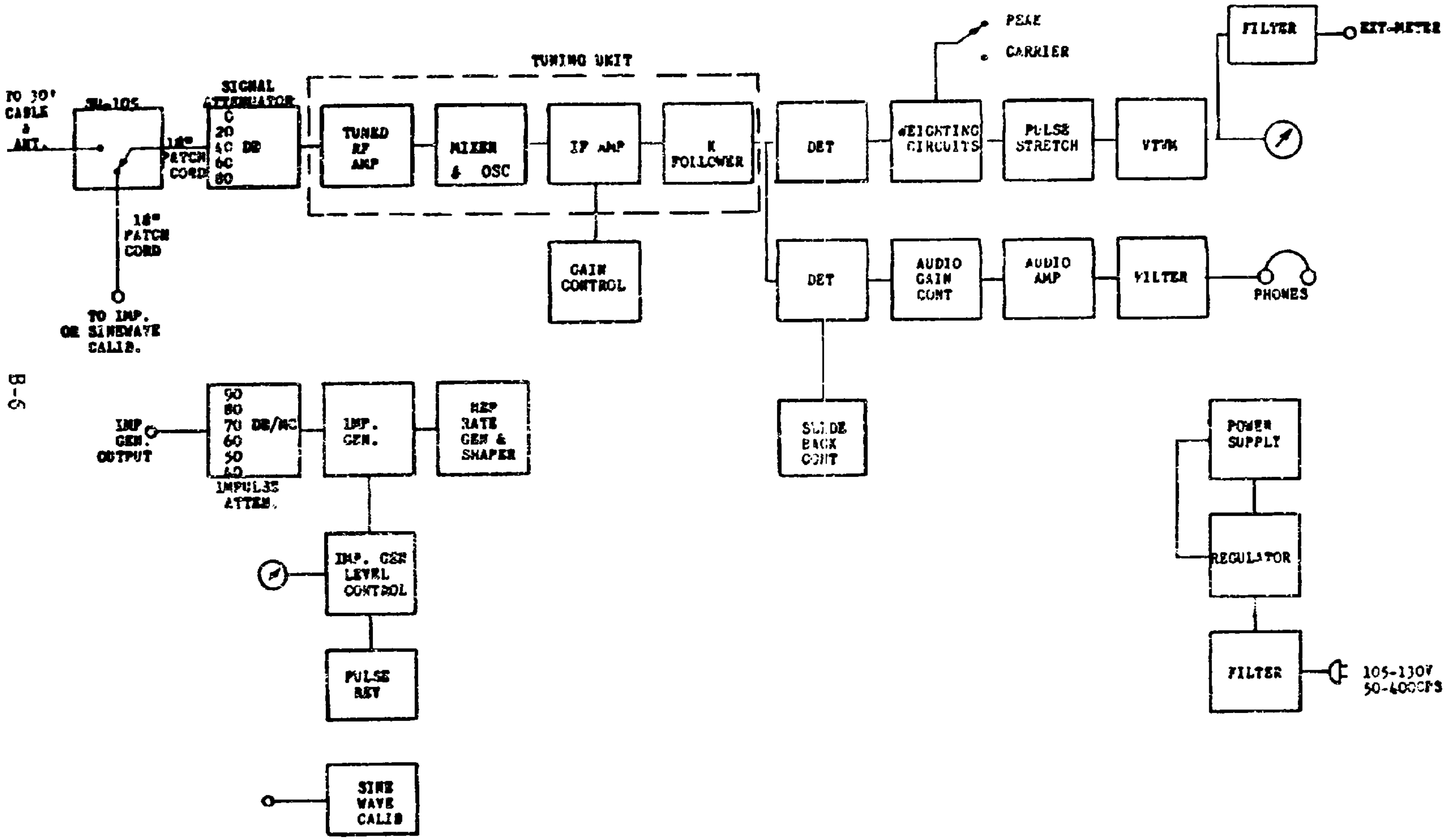


Figure B-5. EMPIRE/NF-105 block diagram.

BLOCK DIAGRAM
NF-105

B-6742

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